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Amateur Astronomy

It is quite probable that the literary purist will see a certain inappropriateness in the above juxtaposition of words. He will sense immediately that the word *amateur,* a substantive, is here given the rôle of a modifier. Passing over that technical inaccuracy, he may still feel that the word should be fraught with more of the personal than the setting here permits. Nevertheless, it is doubtless true that the meaning which these words are intended to convey will not be missed by any amateurs in astronomy. This and similar phrases have become intelligible to members of this extensive though informal fraternity through frequent usage in recent years.

A more subtle misunderstanding may arise in the mind of the astronomically uninitiated and less thoughtful person upon reading these words. To him *amateur astronomy* may mean astronomical work of an inferior quality done by those who are inadequately fitted for the task they have undertaken. The true meaning, however, lies in quite a different direction. The emphasis is not upon the character of the results attained but upon the spirit and attitude of mind with which the work is pursued. In a word, *amateur astronomy* is the astronomy of those who find pleasure and even exhilaration in it.

This will mean that frequently amateur astronomy is work done without expectation of material compensation; it is often merely an avocation, serving as a relief from the daily monotony of toil. It may, and often does, mean that the work done is of the highest order and often merits and receives the approbation of those best qualified to evaluate its worth.

Astronomy, perhaps more than any other one of the sciences, affords a field for the amateur. The scope of it is unlimited, the material is available to all, the necessary physical apparatus is negligible. One need only step out of doors on a cloudless night to find himself in his laboratory. He need take with him only those faculties which no normal person can leave behind, namely, eyesight, and intelligence, and imagination.

Thus equipped, he will view the beauty of the perennial sky, he will comprehend, at least in part, the phenomena presented to him on a vast scale, he will dream dreams of things to come.

He may thus become an astronomical amateur.

Recent Results on the Distribution of the Spirals

By PAUL D. JOSE

When we think of nebulae we are inclined to think of a cloudy mass of matter. However, there are the Spirals which have unfortunately been called nebulae because of the manner in which they were first seen; i.e., with the naked eye. Visually, these objects do not resolve themselves into stars but present the appearance of cloudy aggregations. Thus the name nebulae. Later, with the introduction of prolonged photographic exposures, their detailed structure became apparent and they were called spiral nebulae. It might be well, as has been suggested by some astronomers, if the name could some how be shortened to just "Spirals," and so remove any ambiguity as to their identity.

The French astronomer, Messier, was the first to make a catalogue of the positions of so-called nebulae and small clusters of stars. He was interested in seeking comets and all too frequently experienced the joy of finding something which looked like a comet, but which, with repeated observations, refused to budge from its original position, thus betraying its identity as different from that of a comet. It was to do away with this repeated discouragement that Messier compiled his catalogue (1781).

No appreciable interest was taken in these so-called nebulae until in 1783 when Sir William Herschel began his study of the sky with an 18-inch reflector. He found and described more than 2,500 nebulae and clusters. His son, John Herschel, carried out this program in the southern hemisphere and in 1864 the results were published in the form of a General Catalogue.

In 1888, J. L. E. Dreyer compiled the New General Catalogue, giving the positions of more than 13,000 objects. Most of the star clusters and brighter spirals are known today by the numbers assigned to them in this catalogue; as for example, the Great Nebula in Andromeda is referred to as N.G.C. 224. Messier's designation for this is M31.

It was William Herschel's earlier view that all nebulae were "resolvable" if only a sufficiently large telescope were used, and that many were "island universes" or sidereal systems; a view which he began to modify about 1791 because of the discovery of objects which he believed composed of bona-fide nebulous matter. The belief that all objects of the spiral class were composed of nebulosity held sway with but few exceptions throughout the 19th century. It was not until the discovery of novae in the spirals in 1917 that the character of these objects as island universe was championed by H. D. Curtis and others.

Before taking up the most recent results on the "Distribution of the Spirals," it will be entertaining to mention the views held by some of the earlier writers.

R. A. Proctor, writing in the *Monthly Notices* (1869), mentioned two features in nebular distribution, (1) the nebulae presented a streamy appearance, (2) there was a zone of "dispersion" (a zone in which no nebulae were seen) coinciding with the Milky Way.

The positions of the nebulae, when plotted on the celestial sphere, showed these objects to be distributed in streams at the end of which there were apparent aggregations; emphasized in the southern hemisphere by the Magellanic Clouds. This coincidence led Proctor to the conclusion that the Magellanic Clouds and the nebulae were part of the same system.

There were two views regarding the nature of the nebulae: either they belonged to the galactic system, or they lay outside of it. Upon dividing the observable objects up into five classes, clusters, easily resolvable clusters, resolvable globular clusters, resolvable nebulae, and irresolvable nebulae, Proctor observed that these objects lay near the plane of the Milky Way according to their resolvability. The resolvable objects lay in or near the plane, and as their resolvability diminished they tended to aggregate more into higher galactic latitudes. It was this line of reasoning which lead to the association of the nebulae with our own sidereal system.

The alternative of assigning the nebulae to outer spaces and of attributing the zone of "dispersion" to an absorbing stratum lying in the galactic plane was considered, but rejected on the grounds of the above classification.

An interesting speculation on the formation of the nebulae was that made by Bohlin who "suggests that the universe has been formed by the breaking down of a great spheroidal shell of matter of which the equator formed the Galaxy, and the debris of the polar regions the spiral nebulae."

Today, these spirals are definitely recognized as external systems, lying at tremendous distances. Their similarity with our own galaxy is established. Within the last few years very interesting work has been done pertaining to these objects. The names connected with the study of their distribution includes those of Shapley and Miss Ames[1], Mayall[2], and Hubble[3].

Hubble, working with the instruments at Mt. Wilson, has given the most comprehensive and systematic study to this characteristic. The following diagram gives the results of the data accumulated by him.

In Figure 1 each dot, disk, or dash represents a point in the sky photographed with either the 100-inch or 60-inch reflector. The character of the dot indicates the number of nebulae counted on the plates; the number being corrected for zenith distance, plate quality, and other factors which tended to reduce the number actually registered. The small dots indicate that the number of nebulae counted on each plate lies ap-

[1] *Ann. H.C.O.*, **88**, 2, 1932. [2] *Lick Obs. Bull.*, **16**, 458, 1934. [3] *Ap. J.*, **79**, 8, 1934.

proximately between 40 and 160; the large dots the number, between 160 and 330; and the circles, the number between 20 and 40. When a cross is added to the large disk the number exceeds 330 and when a cross is added to a circle, the number is less than 20. The dashes represent regions in which no nebular images were found. Each plate covers less than a square degree of sky. The regularity of distribution of the areas examined by Hubble is worthy of special note. In this feature Hubble's survey definitely surpasses all other similar investigations.

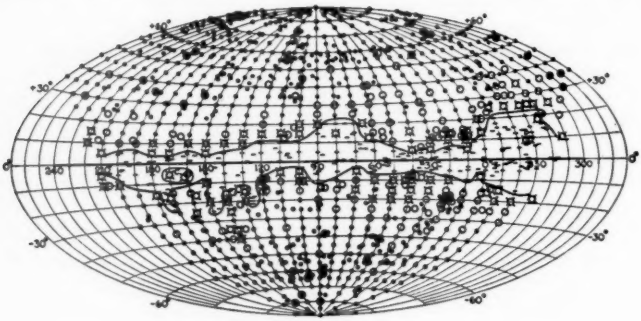


FIGURE 1
DISTRIBUTION OF THE NEBULAE (HUBBLE)

The region outlined by the dashed areas coincides roughly in position with the Milky Way. This region of avoidance is irregular in contour, and large flares where nebulae are rare or wanting entirely protrude from it on either side. The one in the region of Ophiuchus ($\lambda = 330°$) and the one in Taurus ($\lambda = 140°$) are of special interest.

Inclined about 12° to the galactic plane there is a belt made up of the brighter Helium or B-stars. The extremities of this belt, farthest from the galactic plane, are to the north in the constellation of Ophiuchus and to the south in Taurus. In other words, the flares in these constellations coincide in position with those parts of the Helium belt of stars which are farthest from the galactic plane. Regions of "partial obscuration" extend to the highest latitudes at the tips of these flares.

There is a general unevenness in the whole pattern as outlined by the

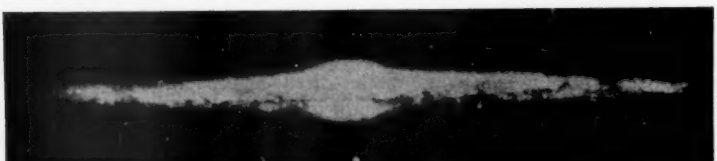


FIGURE 2
N. G. C. 4565

lines which encompass those regions in which no nebulae are to be found. Examining a photograph of the edge-on spiral N.G.C. 4565 (Fig. 2) it is seen that the dark belt across the major axis presents a very mottled appearance, suggesting that it is not a continuous mass but evidently made up of clouds lying more or less scattered. Allowing a comparison between this spiral and our own galaxy it can be concluded that the obscuring matter which prohibits us from seeing nebulae is not a uniform layer but consists of clouds lying one behind the other. At some latitudes they lie farther from the plane than at others giving the rough outline as mentioned. This moreover, according to Hubble, would account for the appearance of nebulae at lower latitudes, inside the region defined as the "zone of avoidance." Such regions are seen in Ophiuchus, Taurus, and Cepheus ($\lambda = 80°$). The center of the galaxy lies near the region of Ophiuchus and at this longitude a few nebulae are seen at latitude 10°. The anticenter lies near the region of Taurus where nebulae are seen about 5° from the galactic plane. Towards the anticenter the obscuring matter is much less, and on the assumption of scattered clouds the chance of finding a visible opening between clouds is much greater at low galactic latitudes towards the anticenter than at corresponding latitudes towards the center. The general trend of the number of nebulae found on a plate for low latitudes increases as the observations are made away from the galactic center, with the exception of the regions lying off the flares in Cepheus and in Taurus. This is apparent from an examination of the positions of the small dots which indicate "normal distribution." One of the positions, marked A at latitude 35° and longitude 335°, shows no nebulae. This region lies off the flare in Ophiuchus. From the number of crossed circles it is not surprising that this plate should show no nebulae.

The north celestial pole lies at $\lambda = 90°$ and $\beta = 28°$ near the edge of the Cepheus flare and in a region of partial obscuration. Hubble has suggested that this may affect the magnitudes of some of the stars in the North Polar Sequence.

Following is a brief summary of Hubble's data:

Polar Caps	$\beta = 40°$ to 90°	
North	426 fields	giving 21,359 nebulae
South	215 fields	giving 10,824 nebulae
Galactic Belt	$\beta = 0°$ to 40°	
North	336 fields	giving 5,868 nebulae
South	306 fields	giving 5,150 nebulae
Total	1,283 fields	giving 43,201 nebulae

These fields cover an area of about 650 square degrees, or about 1.5 per cent of the whole sky. Any conclusion drawn from this sample should be a fair representation of the sky as a whole.

It can be shown that for uniform distribution in space

$$\log N = 0.6\, m + \text{const.}$$

where N is the number of nebulae per unit of area down to a limiting magnitude m. It is seen at once from this equation that if m increases

by one-half, the number of nebulae should increase by a factor of two. This is demonstrated very clearly by the figures given by Shapley and Miss Ames in the case of nebulae down to the limiting magnitude 13. Their figures are:

Magnitude Interval	Number
10.0	20
10.0-10.4	13
10.5-10.9	37
11.0-11.4	74
11.5-11.9	147
12.0-12.4	259
12.5-12.9	475

It might be noted that if the nebulae which are included in this count are plotted according to their positions on the celestial sphere, they do not lie at random but have a streamy nature in their distribution as was pointed out years before by Proctor. Yet, from this small sample, a small fraction of the nebulae which are accessible to the modern telescope, we are not justified to make any conclusions as to normal distribution.

Hubble and Mayall each assumed that data from regions in the polar caps ($\beta \geqslant 40°$) represented nebular distribution alone, and that the apparent distribution in the galactic belts was influenced by the local galactic obscuration.

In assigning magnitudes to the spirals it is necessary to take account of the red shift; i.e., there is a shift of the spectrum to the red which causes a decrease in the photographic brightness and consequently the objects appear fainter, and the observed magnitudes must be corrected.

For the 60-inch and 100-inch reflectors, Hubble arrived at the relation

$$\log N = 0.6\,m - 9.12$$

where m is the limiting magnitude corrected for the red shift.

Mayall, in his determination of the distribution of the spirals used 489 plates taken with the Crossley reflector. More than half of these were taken by Keeler, Perrine, and Curtis. These plates were not distributed uniformly over the sky. Due to the manner in which the plates were treated, Mayall found it expedient to consider them in two classes when determining "normal distribution."

135 plates with $\beta \geqslant 40°$ taken by Mayall (1932-33)
208 plates with $\beta \geqslant 40°$ taken by Keeler, Perrine, Curtis

His own data may be summed up as follows:

1932-33 Plates

	m	m	m
Exposure time	20	60	180
No. of plates	47	76	12
$\overline{\text{Log N}}$	1.30	1.74	1.95
Corr m_L	18.1	18.8	19.05

where $\overline{\text{Log N}}$ is the mean value of log N for the plates of each group of exposure times, and corr m_L is the limiting magnitude corrected for

the red shift. From the accumulated data Mayall found

$$\log N = 0.65 \text{ corr. } m_L - 10.47$$

His results substantiate the conclusions of Hubble.

The work of Shapley and Miss Ames was concerned with the brighter spirals. Their survey lists 1249 objects of which 125 are brighter than the 13th magnitude and 20 brighter than the 10th. The plates used were taken with the patrol cameras in the northern and southern hemispheres and cover the entire sky.

The distribution of these spirals is:

Magnitude	North Decl.	South Decl.	Total
>10	10	10	20
10.0-10.9	33	17	50
11.0-11.9	124	97	221
12.0-12.9	371	363	734
13.0-13.3	100	124	224
Total	638	611	1249

There is an approximate equality in the northern and southern skies, but when referred to galactic coördinates there is a large difference in the numbers between the northern and southern hemispheres. For those with $m > 13.0$ the distribution is

North Galactic Hemisphere	685
South Galactic Hemisphere	340

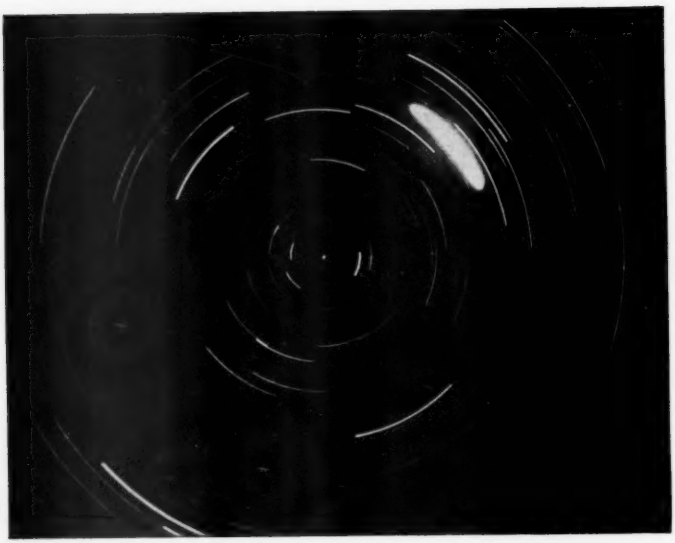
According to the theoretical value for N, the greater part of the nebulae are to be found in the last limiting magnitudes that can be reached. Their numbers increase so rapidly that at about the 21st magnitude for a unit area around the galactic poles, they equal the stars in number. At such faint magnitudes they are so distant that their images can scarcely be distinguished from those of stars. Hubble finds that down to a limiting magnitude 21.25, log N would be 3.25 per square degree; i.e., in one square degree of sky at this limiting magnitude it should be possible to photograph 1780 nebulae; or barring the decrease due to obscuring matter there should be 75,000,000 over the entire sky.

A Photographic Illustration of Precession

By F. R. SULLIVAN

The accompanying prints show two sets of polar star-trails, photographed at the Yerkes Observatory in 1925 and in 1935. The camera, having a photographic objective of six inches aperture, was kept stationary on the roof of the observatory, and the stars were permitted to drift for approximately 2½ hours on each plate. Such exposures have frequently been made for the purpose of recording meteor trails; and from our collection two plates, having an interval of about ten years, were chosen.

1935



1925

It will be noticed at once that the star-trails are not identical in the two photographs. This is especially clearly shown by the trails nearest the pole (which of course are the shortest). Thus, the almost point-like star-image in the left-hand picture, belonging to the present "Polarissima," is distinctly drawn out into a trail in the right-hand picture. Other near-by trails confirm this shift of the pole.

The effect is obviously produced by the precessional motion of the axis of the earth. As is well known, the attraction of sun and moon upon the equatorial bulge of the earth produces a slow rotation of the axis of the earth, each cycle lasting approximately 26,000 years. Within this interval of time the pole describes a small circle around the pole of the ecliptic, the radius being 23°.5. Accordingly, in ten years the pole describes approximately 3½ minutes of arc of a great circle. The scale of the photographs may be ascertained from the fact that Polaris—the overexposed trail on the plate—is now at a declination of 88° 57′. Remembering that the annual variation of Polaris is about +18″ in δ and $+34^s$ in α, we can easily compute the shift of the pole in the sky and verify the observed shift in the center of curvature of the star-trails.

Photographs of this sort should be valuable for purposes of instruction. Since precession does not alter the configuration of the stars in the sky we cannot show its effect in ordinary guided exposures. It is only by means of trails which actually define the position of the pole in the sky that we are able to give an illustration of this phenomenon.

YERKES OBSERVATORY, JANUARY, 1936.

Recent Progress in the Study of Reflection Nebulae

By OTTO STRUVE

Sir William Herschel, in the last quarter of the eighteenth century, had recognized the fact that many nebulae could not be resolved into stars, even in his most powerful telescope, and were therefore composed of an unknown substance which he designated as a "shining fluid." This opinion was challenged in the early part of the nineteenth century because an ever-increasing number of objects, formerly considered as nebulae, were found to consist of discrete stars. Even the Orion nebula and the "Dumb-bell" nebula were thought by competent visual observers to be resolved into many faint stars. However, the existence of Herschel's "shining fluid" was unexpectedly verified by Sir William Huggins when he, on August 29, 1864, pointed his spectrograph toward a bright planetary nebula in Draco. The spectrum consisted of distinct bright lines, without any continuous background, which is the characteristic feature of ordinary stellar spectra. During the following four years Huggins examined the spectra of about 70 nebulae and found that

one-third of them had gaseous spectra. The rest, like the Andromeda nebula, gave continuous spectra, and were, therefore, believed to consist of separate stars.

The next important step in the interpretation of nebulae was made by V. M. Slipher, in December, 1912, at the Lowell Observatory. It was then fairly generally recognized that the irregular diffuse nebulae, like the one in Orion, and the so-called planetary nebulae, consisted of luminous gases under low pressure, while the spiral nebulae and related objects were in reality clusters of stars. One of the most interesting irregular nebulae is the one which envelops the brighter members of the Pleiades cluster. Discovered visually by Tempel in 1859 this nebula had been photographed by the brothers Henry, by Roberts, and by many others, and had led to the idea "that all the clustered Pleiades constitute, as it were, a second Orion trapezium in the midst of a huge formation of which Tempel's nebula is but a fragment."

Slipher succeeded in photographing the spectrum of this nebula in the vicinity of the bright star Merope. He found it to be continuous, with a number of absorption lines: $H\beta$, $H\gamma$, $H\delta$, $H\epsilon$, $H\zeta$, He 4026, He 4388, He 4472. The whole spectrum was "a true copy of that of the brighter stars of the Pleiades" and contained "no traces of any of the bright lines found in the spectra of gaseous nebulae."

Thus, a new type of nebula had been discovered, which consisted neither of separate stars nor of a luminous gas, but which, in Slipher's opinion, could be "disintegrated matter similar to what we know in the solar system, in the rings of Saturn, etc.," and which "shines by reflected star light." As seen from the nebula Merope would be almost as bright as the full moon. Accordingly, "a surface located as is the nebula should be sufficiently illuminated by the star light to be visible."

This idea was developed in 1913 by E. Hertzsprung who measured the surface brightnesses of several points in the nebula and compared them with extra-focal star images of the brighter Pleiades. He found that a perfectly white diffusing screen placed in the position of the nebula and illuminated by the brighter Pleiades would appear to us from 4 to 5 magnitudes brighter than the nebula. Accordingly, the latter is not a perfect scatterer. Evidently the particles are not white, nor do they form a continuous screen. Hertzsprung suggested that if the particles reflect only one-tenth of the incident star light, their combined cross sections would cover only about 0.4 of the total area.

Slipher, and especially Hubble, have obtained spectroscopic observations of a considerable number of diffuse nebulae. The latter lists 29 objects with emission spectra and 33 with continuous spectra. Since, however, nebulae having emission spectra are more easily found, Hubble believes that diffuse nebulae with continuous spectra are really more numerous than those with bright lines.

In 1922 Hubble announced that practically all diffuse nebulae are associated with stars from which they receive their light. Almost with-

out exception, stars of spectral type earlier than B1 are associated with nebulae having emission spectra, while stars of type B1 or later are associated with nebulae having continuous spectra. Almost simultaneously Russell and Hubble suggested that in the gaseous nebulae the light of the associated stars is in some way transformed into monochromatic radiations, while in the nebulae having continuous spectra it is scattered without change in character. Hubble supported this contention by a series of accurate measurements of the angular separations between the exciting stars and the most distant patches of nebulosity visible on his photographs. If the light of the stars follows the inverse square law in its propagation through space and if the nebulous patches scatter the intercepted light in all directions, there must be a definite relation between this maximum angular distance and the apparent brightness of the star. It turns out that, if the brightnesses of the stars are expressed in stellar magnitudes and in place of the distances their logarithms are used, this relation is a straight line the constants of which Hubble was able to compute from a determination by Seares of the limiting surface brightness, expressed in stellar magnitudes per square second of arc, obtained with a reflector of focal ratio 1 : 5 for a given exposure time and a given photographic emulsion.

The observations fully confirmed the predicted relationship: emission nebulae as well as continuous nebulae gave points clustering around the same straight line.

The importance of this result is obvious. Hubble summarized his work in the following words: "The data can be represented on the hypothesis that diffuse nebulae derive their luminosity from involved or neighboring stars and that they re-emit at each point exactly the amount of light radiation which they receive from the stars." Since gaseous nebulae give the same result the interpretation is suggested "that within the spectral limits to which Seed 30 plates are sensitive the continuous radiations from the stars are absorbed by the nebulosity and completely re-emitted as discontinuous radiations within the same range of wavelengths."

Hubble's exhaustive investigation is the foundation of all modern work on galactic nebulae. In 1926 Menzel and Zanstra independently discovered the true mechanism by which continuous radiation from the stars is converted into monochromatic nebular emission. Since that time a large amount of work has been done by various investigators on the interpretation of the spectra of gaseous nebulae. Relatively little progress, on the other hand, has been made in the study of nebulae having continuous spectra.

In order to advance our knowledge of interstellar matter, in general, and of reflection nebulae, in particular, we need information concerning the physical properties of the reflecting material. Before a new theory of reflection nebulae can be proposed, we must know whether the particles are large or small, whether they scatter light selectively, as does

the atmosphere of the earth, or non-selectively, as do the rings of Saturn.

An important advance was made by Zanstra in his 1927 paper, in which he refined Hubble's original mathematical treatment and assumed that the light intercepted by the nebular particles is not scattered uniformly in all directions, as Hubble had assumed, but that it is scattered uniformly over one hemisphere, leaving the other hemisphere completely free of scattered light. From a rediscussion of Hubble's observational data Zanstra found that the nebulae do not reflect all incident light, but that there is a certain lack of efficiency in the scattering power of the nebulae, which is measured by a difference of 1.2 mag between the observed and the computed surface brightness of the nebulae. This would correspond to an albedo of about 30 per cent—a value which seems entirely reasonable. It includes, of course, not only the true albedo of the nebular particles, but also the effect of open spaces between these particles. That such spaces actually exist is demonstrated by the fact that in many cases the background of faint stars can be seen through the nebula. The latter are, therefore, not always perfectly opaque.

While these investigations were in progress, Barnard, Max Wolf, and others made important contributions to our knowledge of another type of nebulae—those which appear as starless regions in the Milky Way and "are produced by the interposition of huge obscuring clouds between us and the remoter stars." Barnard had clearly shown that there was a close connection between dark and bright nebulae; and Russell, in 1922, stated the case as follows: "The transition from these dark nebulae to luminous nebulae in the vicinity of the stars appears to occur in two ways. The first is by simple reflection of the light of the stars—which appear to occur in the nebulosity surrounding the Pleiades, the star ρ Ophiuchi, and probably in many other cases. The second is by the excitation of gaseous emission, as in the Great Nebula of Orion, which is connected with one of the greatest known regions of obscuration and itself shows signs that obscuring masses lie in front of it."

By means of a method originally developed by Pannekoek the distances and absorptions of several dark clouds have been determined in recent years. In some of them the absorptions are quite large, and it is probable that the densest portions of the more conspicuous dark markings of Barnard are practically opaque.

Where they are not completely opaque, distant stars can be seen through the screen of absorbing clouds. For several such regions the color indices of these distant stars have been measured, and some of them have been found to be appreciably redder than they would appear to us normally. However, there are indications that at least in some dark clouds the reddening is less than would be observed if Rayleigh scattering were responsible for both the general opacity and the selective absorption of violet light. It is, therefore, probable that non-selective dimming of starlight by obstructing particles which are too large to give

color-effects is in part responsible for the appearance of the dark clouds.

At the same time we now know that there is in interstellar space an irregular medium which produces appreciable reddening in all very distant stars located in or near the Milky Way. This medium is not coincident with the interstellar substratum of calcium gas, but, similar to it, it is more concentrated in some regions of the galactic plane than in others. The latest investigation by Stebbins and Whitford of the color-excesses in globular clusters—objects which are among the most distant members of our galaxy—shows that "there is a close relation between the color excess and the space absorption, as shown by the number of extra-galactic nebulae in the field of a globular cluster." However, "the reddest clusters may or may not be located in heavily obscured areas."

Unfortunately, the evidence for or against reddening in obscuring nebulosities is not entirely conclusive. Seares has found that the color-excesses of stars are also correlated with the numbers of extra-galactic objects seen in each field. His result and that of Stebbins and Whitford prove that in regions where the obscuration is not very large the reddening increases with the obscuration. But whether very dense dark markings also produce an excessive amount of reddening is not known at present. Observations in the southern Coal Sack by W. Becker gave only a very slight excess of color for stars located in and near the obscured region. Similarly Schalén found selective absorption between λ 4400 and λ 3950 amounting to 0.2 mag, 0.2 mag, and 0.07 mag in the obscured regions of Auriga, Cygnus, and Cepheus, respectively, while in the same regions the photographic absorptions were 1.9 mag, 1.5 mag, and 0.9 mag. From these data it would seem that the ratio between the selective and the general absorption in dark clouds is less than the value accepted for interstellar space, in general, which is of the order of 0.5.

The methods based upon the color excesses of distant stars are not fully satisfactory, because there are only few stars for which the spectral types are known, and because it is often difficult to decide whether a star is behind the obscuring screen or in front of it.

In 1920 Seares and Hubble discovered that forty-seven stars surrounded by nebulosity exhibited positive color excesses; the color indices of these stars were approximately half a magnitude redder than the average color indices corresponding to their spectral types. This effect was tentatively attributed by the authors to selective scattering within the nebulae, although other explanations were also mentioned. Several nebulae, the central stars of which had positive color excesses, gave continuous spectra. A few years ago G. Shajn published a new discussion of the observational material collected by Seares and Hubble. He pointed out that many of their stars were very far away and would, therefore, be appreciably reddened by interstellar matter. Several least-squares solutions of the material led to a reddening attributable to the nebulae proper of about 0.15 mag. Since we do not know how much

the same stars are dimmed by the intervening nebulosity, we cannot determine the ratio of the selective to the general absorption, and thereby hope to learn something regarding the physical nature of the nebular particles.

Obviously, it is very important to determine whether or not there are selective effects in nebulae having continuous spectra. If such effects are present and if they follow the law of Lord Rayleigh, the particles must be exceedingly small. If, on the other hand, selective effects are absent we shall be inclined to believe that the particles are relatively large, resembling perhaps the particles in the rings of Saturn or in the Zodiacal light. Particles of intermediate sizes may give rise to rather complicated color-effects, which may even result in a reversal of the usual reddening. Such effects have been investigated theoretically by Mie, Götz, Blumer, etc., and in the laboratory by Stratton and Houghton. Quite recently these theories have been applied by Schalén, Mrs. Rudnick, and others to the interpretation of the energy curves of reddened B-type stars.

Rayleigh's law for scattering by very small particles leads to a value of the scattering coefficient which is inversely proportional to the fourth power of the wave-length. The amount of transmitted light decreases as

$$e^{-\sigma lN}$$

where σ is the scattering coefficient for each particle, l is the length of the path traveled by the light within the scattering medium, and N is the number of particles per unit volume. Since σ is large for violet light and small for red light, there is always a certain amount of reddening. Since, however, σ enters in conjunction with lN, the reddening is large only in a medium in which the path is long and the density is great.

The amount of radiant energy by which the transmitted beam is depleted is scattered by the medium in all directions. Observed from the side this scattered radiation is relatively rich in violet and blue light, and poor in red light. Unless the incident radiation is already appreciably reddened, the energy distribution of the scattered light is inversely proportional to the fourth power of the wave-length, irrespective of the values of N and of l. Accordingly, it is always a definite amount bluer than the incident light, no matter whether this light is itself red or blue, and no matter whether the medium is dense or thin. If the medium is dense the scattered light will be intense; if it is thin, the scattered light will be feeble. But its color is always by the same amount bluer than that of the incident light.

Suppose we observe a scattering medium visually, at say λ 5600, and photographically, at λ 4400. Then the ratio of the intensities of the original source to the intensities of the medium will be $(4400)^4/(5600)^4 = 0.38$. In other words, if we make an exposure of the medium long enough to show the region at λ 5600 of the same density as in the source, the density at λ 4400 in the medium will be $1/0.38 = 2.6$ times stronger. Measured in stellar magnitudes we should find the photographic image

about one magnitude stronger in the medium than in the source. If the star is of type A with a color index of zero, the nebula should have a color index of —1 mag, which is considerably bluer than the bluest known stars. If the star is of the solar type with a color index of +1.0 mag, the nebula should be similar in color to an A-type star, etc.

It should be relatively easy to measure such large differences in color index. A first attempt was made by Struve, Elvey, and Keenan in 1933 for the nebulae near Merope and Maya, in the Pleiades. From a small-scale spectrogram the difference in color index between nebula and star was found to be +0.3 mag, the nebula being bluer than the star. A series of photoelectric observations with light filters gave +0.2 mag. The precision of these observations was rather low, and they merely prove that there is no Rayleigh scattering. Whether the small tendency of the nebula to be bluer is real cannot be decided without additional observations.

A more elaborate series of observations was undertaken by Struve, Elvey, and Roach during the summer of 1936. A new Schmidt camera having a spherical silvered Pyrex mirror and a correcting plate of 94 mm aperture and 180 mm focal length was used to photograph a number of nebulae on an ordinary photographic emulsion without a filter and on a panchromatic emulsion with a yellow filter. Because of the favorable light ratio of the instrument it was possible with relatively short exposures to obtain on the plates a density of the sky background that was suitable for accurate measurement. The nebulae appear projected upon this background and are measured with a microphotometer from this background as standard.

In this work particular attention was devoted to the nebulous region around the star ρ Ophiuchi. Discovered visually by Barnard, during his comet-sweeping days, it was announced by him some ten years later after successful photographs with the Willard lens had shown the unusual extent and the remarkable structure of this nebula. The best existing photographs are in Barnard's *Atlas of Selected Regions of the Milky Way* and in Ross' and Calvert's *Atlas of the Milky Way*. A large dark cloud, almost opaque in the center, is illuminated by a number of fairly bright stars, each giving a distinct luminous nebula. The spectrum of the most conspicuous of these, around ρ Ophiuchi, was found by Slipher to be continuous. Because the stars are quite far apart, and the nebulae are not so hopelessly confused as in the Pleiades, this region is probably the most suitable in the sky for a study of reflection nebulae.

However, the most intriguing feature of this particular region, which suggested it for investigation, is a feebly milky nebulosity surrounding the first magnitude star Antares. Antares is located less than one degree from the southern edge of the opaque cloud in Scorpius and Ophiuchus. Although Barnard, in his earlier work at the Lick Observatory, was inclined to attribute the faint glow around Antares to halation, he wrote in his later *Milky Way Atlas*: "The nebulosity extends southward

(from 22 Scorpii) in wave-like forms over Antares and even beyond τ Scorpii." The slightly unsymmetrical glow is clearly shown on several photographs of the *Atlas* by Ross, and it strongly suggests a connection between the dark cloud and this bright star.

But Antares is a notoriously red star. Its spectral class is cM0, and its color is, even to the unaided eye, strikingly red. We have here an ideal case for testing the reflection theory of the diffuse nebulae. If the feeble glow north of Antares is produced by non-selective scattering in the outer portions of the dark cloud, its color must be similar to that of Antares itself. The color index of a giant M0 star is about +1.7 mag. The actual color index of Antares is listed by Öpik as +2.06 mag. Accordingly, the nebula should be a striking object if photographed on a red-sensitive plate.

The observations secured with the Schmidt camera fully confirm these expectations. Even on the best violet-sensitive photographs the nebula near Antares is exceedingly faint. On the contrary, on the panchromatic plates taken with a yellow filter it is the most conspicuous object in the entire field. An enormous diamond-shaped red nebula extends principally towards the north from Antares, its greatest distance from the star being somewhat more than one degree. This nebula almost reaches the star 22 Scorpii, which is itself surrounded by a blue nebula hardly shown on the yellow-sensitive plate. There can be no doubt at all that the dark cloud produces the red glow from Antares, like a cloud of smoke reflects the outbursts of a distant fire.

The other bright stars in the Scorpius-Ophiuchus region belong to spectral classes B1 to B5. The color of these stars is blue, and it is therefore no longer surprising that the nebulae surrounding them are bluer than the red nebula near Antares. Nevertheless, it was somewhat unexpected when the yellow-sensitive plates revealed only the barest traces of these nebulosities, while the violet-sensitive plates showed them conspicuously.

Now, it should be remembered that on photographs of faint nebulae —and practically all of them are faint—the conspicuousness with which an object is visible on the plate depends upon how much brighter it is than the luminous background of the sky. The red nebula near Antares is therefore redder than the background of the sky, while the blue nebulae surrounding the helium stars of class B are bluer.

This raises the question: just what is the color of the night sky? Very little is at present known concerning this important astrophysical quantity. Visual and photographic observations by the present Lord Rayleigh show that the color of the night sky resembles that of the sun, and not that of the blue daylight sky. Elaborate observations made photographically by Dufay confirm this view. He states: *"En résumé il résulte de l'ensemble des observations, en faisant abstraction de la raie de l'aurore, que le rayonnement du ciel nocturne diffère profondément de celui du ciel bleu. Il se rapprocherait davantage de celui du soleil,*

dont il diffèrerait pourtant, à égalité dans les régions vertes et jaunes, par une intensité notablement supérieure dans la région violette et peut-être dans la région rouge."

Special observations made at the McDonald Observatory in Texas, and at the Yerkes Observatory in Wisconsin, lead to a color index of about +0.5 for the night sky near the pole. This would correspond to a star of spectral class F5—slightly bluer than the sun, but much yellower than the blue daylight sky. The color index of the latter is about —0.2, which corresponds to a very blue star of class B.

The results of the nebular observations show that on the yellow-sensitive plate (with yellow filter) the nebula near Antares appears about half a magnitude brighter than the sky background. In other words, its intensity is about 60 per cent greater than that of the sky. Even though the human eye is not very sensitive to small differences in intensity, when these intensities are small, we should expect that the red nebula near Antares would be visible to the eye. Indeed, it can be seen quite clearly with a good pair of binoculars, especially if the light of Antares is shielded by a distant pole or a similar object.

The blue nebulae, on the other hand, are even in their most conspicuous parts only about 0.2 mag brighter, on the yellow-sensitive plate, than the sky. Hence Barnard's remark that "all the nebulosity in this region . . . is so faint that it cannot be seen with the eye even in a powerful telescope." Only fleeting glances of these nebulae were had by him in comet sweeping.

Within the rather low precision of the measurements, the colors of the nebulae agree, in general, with those of the illuminating stars, so that the scattering is essentially non-selective. It is, however, possible that more refined observations will show a small difference in the colors, of the order of that found previously for the Pleiades.

A globular cluster, NGC 6144, is covered by the red nebula. Another cluster, NGC 6121 = M4, is outside the nebula. According to Stebbins and Whitford, both clusters are appreciably reddened, but NGC 6144 is not redder than NGC 6121. Accordingly, passage of light through the material of the red nebula does not appreciably redden it. On the other hand, ρ Ophiuchi, σ Scorpii, and 22 Scorpii, which are involved in the denser portions of the dark cloud, show, according to Seares and Hubble, appreciable reddening. The distance of the inner edge of the dark cloud is, according to R. Müller, about 100 to 150 parsecs. Accordingly, there should be little, if any, space reddening for these stars. Apparently, different portions of the same nebula may act differently.

Perhaps there are also differences in the sizes of the particles in different nebulae. A small nebulous patch near γ Cygni, a yellow star of class F8, has a color almost exactly like that of a star of class B. The observations are not very precise, but there can be no doubt that this nebula is much bluer than the night sky, while the star is of about the same color as the sky. If the light of the nebula really comes from

γ Cygni, as Hubble has suggested because of the appearance of the nebula, we should be forced to conclude that in this cloud the scattering is quite selective, producing a blue nebula from the light of a yellow star. There remains, of course, the alternative possibility that the nebula is illuminated by some of the fainter B and A stars which abound in the large star cloud of Cygnus.

An entirely different method of approaching the problem of the physical properties of nebular particles is from a study of the degree of polarization of the light of a nebula. The importance of this type of information was recognized more than 16 years ago by W. F. Meyer who investigated a number of nebulae at the Lick Observatory by means of a special polarigraph constructed for the Crossley reflector. An earlier investigation by R. K. Young had shown conclusively that the light of the solar corona is radially polarized with a maximum of about 37 per cent. The degree of polarization of the Zodiacal light is at maximum about 15 per cent, in a plane passing through the sun. Both sources give essentially reflected light of the sun, which has been scattered by the particles non-selectively.

On the other hand, laboratory experiments and observations of the blue daylight sky indicate that the polarization in media which give Rayleigh scattering is much more complete. Thus, the maximum polarization of the blue sky is about 70 per cent.

Of the various devices for measuring the degree of polarization, Savart's polariscope is generally regarded the most sensitive. A modification of it has been used in recent years by Lyot for determining the polarization of the moon and the planets. For nebular work this instrument is not suitable because it is essentially intended for visual observations. After thorough experiments in the laboratory and at the telescope, Meyer found it best to use a simple Nicol prism, taking two exposures of the nebula with two perpendicular orientations of the Nicol. However, before passing through the Nicol the light from the source had to be made parallel by a lens after which it was focused upon the plate by another lens. This rather complicated construction can now be avoided by the use of "Polaroid" film manufactured by the Polaroid Corporation of Boston. This gelatin film has the property of polarizing the incident natural light almost as completely as a Nicol, and it can be used directly in front of the plate, as would any gelatin light filter.

The properties of the "Polaroid" have been determined by Ingersoll, Winans, and Krause. The degree of polarization at λ 5000 is more than 90 per cent. It is opaque to ultra-violet light and transmits only a fraction of violet and blue light. In the yellow its transmission is very good. In the infra-red the light is transmitted freely, without polarization. With ordinary blue sensitive plates the exposure times must be increased 10 to 12 times, with panchromatic plates the factor is about 4.

Of the objects investigated by Meyer, only one, namely Hubble's variable nebula, NGC 2261, may be regarded as a true reflection nebula.

The others were spirals, planetaries, and gaseous nebulae, all of which have unpolarized light. Meyer suspected a slight amount of radial polarization in Hubble's variable nebula, but the evidence was rather unconvincing. He concludes "that some of the light may be modified by reflection or scattering by small particles, but the proportion thus polarized does not exceed 10 per cent of the light received from this object."

Observations recently made at the McDonald Observatory with the Schmidt camera and a "Polaroid" film in front of the plate show unmistakable evidence of radial polarization in the outer portions of the nebula surrounding ρ Ophiuchi. The percentage of polarized light has not yet been determined, but it is certainly much less than in the inner corona. It may be of the order of 10 or 15 per cent, although in one tail-like extension pointing almost straight south, the percentage may be somewhat greater. This evidence seems to support the results gathered from the color-observations: the particles certainly do not scatter in accordance with Rayleigh's law, as the polarization is much too small. From Lyot's work we know that the moon and the planets give polarizations of the order of 10 per cent, if the phase-angle is favorable. Accordingly, the particles may be fairly large, although they need not be larger than those forming the Zodiacal light. It is quite possible that a relatively small portion of the nebular light does come from very small particles and that these give rise to such effects as the reddening of ρ Ophiuchi. It is, however, safe to say that most of the light of the nebulae in the Scorpius-Ophiuchus region comes to us from particles of meteoric sizes. The results are not so conclusive for the nebula near γ Cygni. If the blue color of this object is really caused by selective scattering of the Rayleigh type we should expect to find a large percentage of plane-polarized light. If the polarization is weak, we shall have to conclude that the incident light is not that coming from the yellow star γ Cygni. Recently L. G. Henyey, at the Yerkes Observatory, found that the polarization is quite negligible. The contradiction has not yet been explained. The nebula may be of the emission type, but this would be surprising in view of the late type of γ Cygni, F8.

It will doubtless be necessary to extend the color-index determinations, as well as the polarization observations, to a greater number of reflection nebulae. In the meantime we shall think of them as of clouds of particles of all sizes; in some nebulae, such as the Pleiades and those in Scorpius and Ophiuchus the large particles predominate. In others very small particles may predominate. Finally, in those in which we observe simultaneously continuous and emission line spectra there must be a large number of free atoms. Incidentally, this picture of a nebula agrees well with that recently proposed by T. L. Page for certain planetary nebulae.

There is, however, one circumstance that tends to make us feel uncomfortable when we think of a nebula as a cloud containing both free atoms and meteoric dust particles. Zanstra's mechanism for the excita-

tion of the bright-line nebular spectrum is a process that should be present in addition to the normal phenomenon of scattering. Now, it does not seem reasonable to suppose that the composition of the nebulae is related to the spectral types of the exciting stars. Rather should we assume that the composition is independent of the spectral types of the stars.

But in that case we must explain why Hubble's straight line relation is the same for all nebulae—irrespective of whether their spectra are continuous or not. The explanation probably lies in the effect of observational selection. In our photographic work we classify as nebulae all objects the surface brightnesses of which are sufficient to produce a measurable contrast against the background of the sky. In the emission nebulae we observe light coming from two sources: the mechanism of fluorescence and the mechanism of ordinary scattering. In reflection nebulae we have only the second mechanism. It is obvious, therefore, that a much thinner nebula would be seen as such if the spectral type of the exciting star is B0 or earlier, than if the spectral type is later. Therefore, on the average, the densities of the emission nebulae should be appreciably smaller than those of the reflection nebulae.

We have recently made a test of this effect, by the use of estimated degrees of obscuration as measures of the densities of the nebulae. The degree of obscuration can be determined from the number of faint stars in the nebular field as compared with the number of stars in adjoining regions. The result bears out the correctness of our assumption: the absorptions of emission nebulae are, on the average, about 0.6 mag less than those of the reflection nebulae. Hence, their smaller average density just about compensates for the increased amount of light resulting from the mechanism of fluorescence.

The next step in the interpretation of the reflection nebulae is a refinement of the theory. For simplicity it is best to start by assuming that all nebular particles are large enough to scatter light non-selectively. We can then make use of Seeliger's brilliant theory of the illumination of cosmic dust clouds. This theory was first developed by Seeliger some 35 years ago and was applied by him to the photometric observations of the rings of Saturn. The remarkable success of this work as well as of more recent applications of Seeliger's theory to the Zodiacal light are well known.

The essential feature of this theory is that each particle is considered as a small sphere which is illuminated by the star. The amount of light reflected in the direction of the observer can be computed if the law of diffuse reflection of the particle is known. It depends, of course, upon the phase-angle, star-particle-observer, upon the albedo of the particle, and in dense clouds upon the effects of mutual obstruction and eclipsing of the particles. The surface brightness of the nebula is the combined effect of all particles lying within a certain solid angle.

For nebulae which are practically opaque Seeliger's formula takes on

a very simple form. It includes as unknowns the albedo of the particle, the phase-function, and the phase-angle. For the phase-function we can use one of the well-known photometric laws: Euler's is the simplest for computation, but it has no theoretical justification; Lambert's law or the one by Lommel and Seeliger are much sounder theoretically, but involve more computing.

The theory can be applied to a statistical material similar to that collected by Hubble. It then leads to a value of the albedo for those nebulae which are really opaque. Thus, for the nebulae in the Scorpius-Ophiuchus region the albedo is about 0.7—a value that is unexpectedly large. However, it is quite probable that more accurate observations will tend to give smaller values. The average albedo for all nebulae is about 0.3.

Perhaps the most interesting feature of Seeliger's theory is the phase-angle effect, which was absent in the theories of Hubble and of Zanstra. Future work should concentrate on a study of observational features depending upon phase-angle. Not only would this provide a critical test for the Seeliger theory, but it would give us a much clearer insight into the mechanism of nebular scattering.

Consider, for example, a relatively thin sheet of absorbing dust. If a star is in front of the sheet it will illuminate the nebula in such a way that its surface brightness is greatest in the immediate vicinity of the star. The decrease of the surface brightness with distance from the star will depend not only upon the geometrical conditions of the problem, but also upon the phase-function. The effect of the latter is especially interesting when the star lies behind the nebular sheet. In that case the surface brightness of the nebula should be quite small near the star, because each particle will be near the phase of "new-moon" and will, therefore, contribute but little to the total surface-brightness. For greater distances from the star the phases of the particles will become more favorable, with the result that the surface brightness will increase, until the inverse square law for the incident star light will again produce a decline in the surface brightness. The nebulae should, therefore, appear as a ring around the star.

In practice it is difficult to distinguish this phase-effect from effects produced by unequal distribution of nebular matter around the stars. Thus, something resembling a ring is observed near the star 22 Scorpii: the surface brightness of the nebula is surprisingly small in the immediate vicinity of the star, in spite of the fact that the dark nebula is large and very dense. However, accurate photometric measurements are required before we can be certain of the phase-effects in nebulae.

This problem has been attacked quite recently by P. C. Keenan, who has investigated the reflection nebula NGC 7023 in Cepheus, and by L. G. Henyey who has greatly extended the theory of nebular illumination and has applied his results to several nebulae in the Scorpius-Ophiuchus region.

Keenan finds that "for the larger part of the nebula the reflecting power is only slightly greater in red light than in blue, as would be expected if the particles are fairly large." There is, however, "a well-defined portion, in which a red excess of the order of 0.3 mag was found." Slight departures in the colors of the nebulae from their exciting stars have also been found by O. C. Collins, who has started a systematic investigation of the colors of reflection nebulae at the Yerkes Observatory. Similar departures are also evident in the photographs by the present writer and Elvey, obtained with the Schmidt camera of the McDonald Observatory. It is fairly evident that these small departures from the normal colors of reflection nebulae are of particular interest, as they open up a new field of exploration in the domain of nebulae. It is much too early to attempt an explanation of these departures.

Henyey's paper, which will appear in the *Astrophysical Journal*, contains several sets of curves from which it is possible to derive the essential physical properties of the nebulae, if their surface brightnesses are known as functions of the distance from the illuminating star. The method has proved of especial value in the interpretation of the nebulae surrounding ρ Ophiuchi and CD —24°12684. The former is of spectral class B5 and of apparent photographic magnitude 5.1; the latter is of class B3 and of apparent photographic magnitude 8.3. Miss Cannon has, very kindly, re-examined the spectrum of —24°12684 and has confirmed that it belongs to an early subdivision of class B. The original *Henry Draper Catalogue* value may therefore be relied upon. Miss Cannon also states that there is no indication of the characteristics of exceptionally high luminosity. Consequently, the absolute magnitudes of both stars are approximately the same, and since both are near enough to the dark nebula to produce reflection effects, we conclude that their distances from us are also approximately the same. It is, therefore, quite certain that the star —24°12684 is situated deep within the nebula and that its light is reduced by something like 3 magnitudes within the absorbing matter. On the other hand, it is probable that ρ Ophiuchi is outside the nebula, as its light is normal. Now, the remarkable thing about the nebulae surrounding these two stars is that in the immediate vicinity of the faint —24°12684 the nebular surface brightness is greater than in the immediate vicinity of the bright ρ Ophiuchi. The former nebula decreases rapidly in intensity with distance from the star, while in the latter the gradient is slow, and the nebula appears very large on the photographs. This is exactly what Henyey's theory predicts: a star inside the nebula is associated with a steep gradient of the nebular surface brightness, while a star outside is associated with a much smaller gradient. Henyey computes the distance of ρ Ophiuchi in front of the nebula and of —24°12684 below the nearer surface. The results are entirely plausible. The absorption coefficient of the dark nebula comes out rather large: 6 magnitudes per parsec; but this should not be taken too literally. It simply shows, as we already know from

star counts, that the central portions of the nebula are practically opaque.

It may well be that the case of —24°12684 will prove to be of exceptional importance. We have here a star with known spectrum which is situated behind a screen of absorbing negular material of known optical thickness. An effort will doubtless be made next spring to determine the color excess of this star and to derive, if possible, the distribution of energy in its spectrum. We should then be in a position to state whether the transmitted light is appreciably reddened in the dark nebula and whether the ratio of the photographic and photovisual absorptions is the same as in interstellar space.

YERKES OBSERVATORY, WILLIAMS BAY, WISCONSIN.

A Declination Axis Support for a Heavy Spectrograph

By R. WILLIAM SHAW*

The most convenient method of supporting a spectrograph on a reflecting telescope embodies some form of Cassegrainian mirror arrangement either with a bored primary or a modification involving two secondaries. Methods employing the coudé mounting may be used successfully when there are available large mirrors by which the light loss from the many reflections is somewhat compensated. The various modifications of the Newtonian type are not easily adapted to this problem except in the case of lighter weight spectrographs since unduly large flexures may be developed. Moreover the Newtonian type is generally inconvenient from the observer's point of view.

While engaged in an investigation of stellar spectra in the far ultraviolet, it became necessary for the writer to attach a two-prism spectrograph weighing over 100 pounds to a photographic telescope with a light steel frame tube. The instrument utilized an "English" type mounting with a 15-inch "chroluminized" concave mirror and a similarly coated plane mirror arranged as a modified Newtonian. The lightness of the skeleton tube supporting the mirrors prohibited completely any attempt to attach such a heavy spectrograph to the frame with either a Newtonian or ordinary Cassegrainian arrangement of mirrors.

The problem was solved by using two secondaries and a short hollow declination axis through which light passed to the spectrograph supported in a steel cage. The cage was attached to the polar axis in such a manner as to occupy the position of the ordinary counter-balance weights. The arrangement is shown in Figure 1.

The first secondary (S) was the usual convex mirror placed in a support which permitted motion along the optic axis for ease in focusing.

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The smaller secondary (F) was an optical flat placed at an angle of 45° near the end of the hollow declination axis (AA) which passed centrally through the boxing shown at the center of the polar axis. Since the reflectivity[1] of aluminized surfaces at 3000 A is about 80 per cent, there is available after three reflections over 50 per cent of the incident light. The reflectivity increases for the longer wave-lengths.

FIGURE 1

THE TELESCOPE, POLAR AXIS, AND THE SPECTROGRAPH MOUNTED AT THE END OF THE HOLLOW DECLINATION AXIS.

The spectrograph[2] was mounted in the sturdy steel frame or cage shown at the right of the polar axis. The spectrograph was supported almost entirely by a pin (P) which passed through the center of gravity of the instrument. Rotation of the spectrograph was prevented by an adjustable frame (E) which supported the collimator end. The slit was oriented parallel to the plane of the celestial equator.

[1] William and Sabine, *Astr. Jour.*, **77**, 316 (1933).

[2] A description of the quartz spectrograph which embodies a number of new features will be published elsewhere.

This method of supporting a spectrograph has a number of advantages especially for telescopes in which the tube construction is light or in which the primary is not bored for the usual Cassegrainian mounting. The instrument serves as part of the counter-balance thereby removing the necessity of increasing the counter-balance load when the instrument is attached. Moreover the spectrograph support may be as sturdy as desired without introducing any additional stresses in the tube or frame carrying the optical parts.

The change in internal flexure of the spectrograph is a minimum since the instrument always moves in one plane. For ultra-violet spectra stars should be observed as near the meridian as possible and consequently the angle through which the instrument moves during an exposure is small.

Because of the necessity of observing stars at the higher altitudes, the observer at the slit guiding telescope is usually in a comfortable observing position. Moreover as an exposure progresses the spectrograph moves lower and the observing position becomes more comfortable and convenient. In fact the only position in which observing is difficult is that for stars low in the east. In this case the telescope swings directly under the axis and the spectrograph. However, in ultra-violet work such a position is rarely used because of the increased ozone absorption.

The most serious difficulty encountered in this type of mounting is in the guiding. When the spectrograph slit is in a plane perpendicular to the polar axis, it is necessary, of course, to guide in both right ascension and declination unless the star is on the celestial equator. This complication, however, does not become unduly serious unless very wide spectra are desired. The difficulty may be overcome entirely by mounting the spectrograph on the customary rotating ring rather than in a cage as in the present instance. For extensive work on the planets this modification would perhaps be a necessity.

The author wishes to thank the Lowell Observatory staff for the use of the telescope and for their aid and encouragement during the observational work.

Visibility of the Planets for 1937

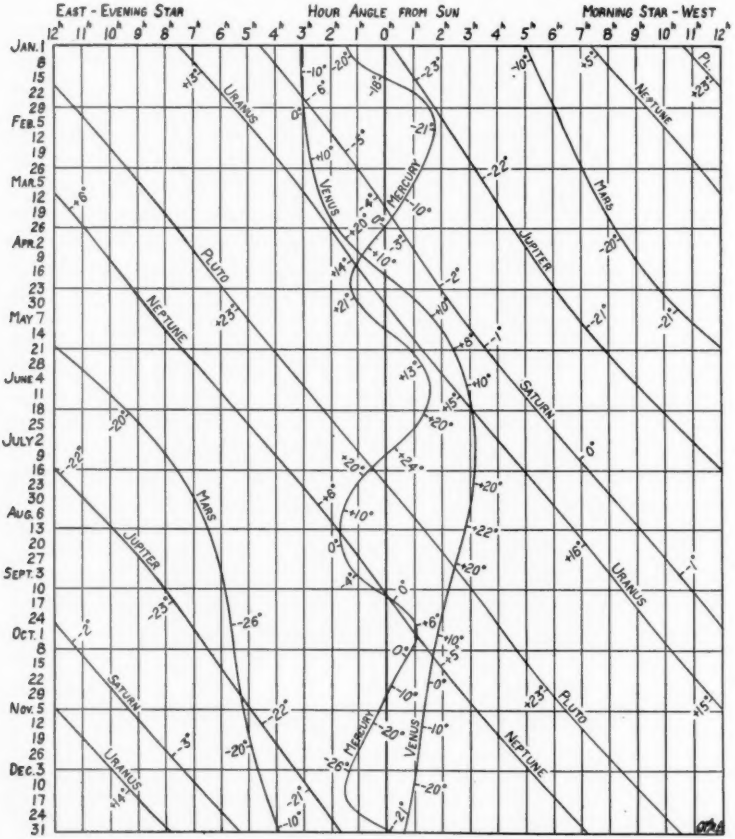
By WILLIAM MALCOLM BROWNE

The visibility of the planets during the year 1937 is shown by the accompanying diagram. It may be used equally well in any latitude.

The path of the sun is represented by the heavy vertical line in the center of the diagram marked 0^h. The lines designated by the names of the various planets show how far east or west of the sun the planets are at any particular date. The declination of each planet is indicated at various points along its path, as it also varies throughout the year and should be considered in determining the visibility of a planet.

A particular planet may be seen at some time of night during any part of the year except when the planet is too close to the sun. When a planet is less than about an hour from the sun, it is generally too close to be visible. In general, the farther a planet is from the sun, the easier it will be to see. Also the planet will be visible for a longer portion of the night.

VISIBILITY OF THE PLANETS FOR 1937



Since the sun is on the meridian, or reaches its maximum altitude, at about noon, a planet will be on the meridian, or reach its maximum altitude, as many hours before noon as the planet is west of the sun, or as many hours after noon as the planet is east of the sun.

When a planet is one or two hours west of the sun, it is generally

possible to see it low in the eastern sky just before sunrise. The planet will appear in approximately the same part of the sky as that in which the sun will be an hour or two later.

When a planet is one or two hours east of the sun, it is generally possible to see it low in the western sky just after sunset. The planet will appear in approximately the same part of the sky as that in which the sun was an hour or two earlier.

The planets, Mercury and Venus, are most easily seen at or near the times of their elongations. These occur when the planet is farthest east or west of the sun.

The visibility of a planet is increased if the planet's declination is favorable. The planet's declination should be plus for best visibility in the north temperate zone, and minus for best visibility in the south temperate zone.

A planet is in conjunction with the sun when its path on the diagram intersects the 0° line. The planets, Mercury and Venus, may have both inferior and superior conjunctions. Inferior conjunctions of Mercury and Venus occur when the planet crosses the 0^h line in an east to west direction, while superior conjunctions of Mercury and Venus occur when the planet crosses the 0^h line in a west to east direction. The other planets can have only superior conjunctions.

A planet is in opposition to the sun when its path on the diagram crosses the 12^h line. Two planets are in conjunction with each other when their paths on the diagram intersect. A planet is a morning star when it is on the right of the 0^h line; it is an evening star when it is on the left of the 0^h line.

Most of the planets are easily visible to the naked eye, except when they are close to the sun. Uranus is just visible to the naked eye under favorable circumstances. Neptune is visible in a small telescope or a good pair of field glasses. Pluto can be seen only with the aid of a fairly large telescope.

WASHINGTON, D. C., DECEMBER, 1936.

Planetary Phenomena in 1937

By HERBERT C. WILSON

ECLIPSES

There will be three eclipses during the year 1937, two of the sun and one of the moon.

The eclipse of the moon will be only partial, about one-seventh of the diameter of the moon's disk being immersed in the umbra of the earth's shadow at the maximum of the eclipse, so that this will be of little interest to students of astronomy.

The total eclipse of the sun on June 8 would be of very great interest except for the fact that the path of totality lies almost wholly over the Pacific Ocean and that there are only a few very small islands favorably situated for observations of

the total phase of the eclipse. This is the more regrettable because the duration of totality at the middle of the eclipse is $7^m\ 4^s0$, which is well up toward the maximum duration that can ever occur.

The duration of the annular phase of the eclipse of the sun on December 2-3 is also extraordinarily long,—$12^m\ 0^s0$ at the middle of the eclipse. The path of the annular phase is also across the Pacific Ocean and has only a few small islands favorably situated for observing stations.

It is interesting to compare the paths of the two central eclipses, especially when drawn on the same map (as I have done on the new *National Geographic Magazine* map of the Pacific Ocean, just received), and notice the similarity, except for the direction of curvature (upward and downward), and the complete avoidance of islands represented by more than the merest dots. The two paths overlap north and northeast of Christmas Island, but the center lines do not approach each other closer than about 75 or 80 miles. Opposite Christmas Island the path of totality of the June 8 eclipse is about 145 miles wide. At the middle of the path, near longitude 130° west from Greenwich, the width is nearly 160 miles. The width of the path of the annular eclipse of December 2-3 in the vicinity of Christmas Island is roughly 200 miles.

The following data concerning the eclipses, as well as those concerning the planets, are taken from the *American Ephemeris and Nautical Almanac* for 1937.

Note: In the tables which follow the longitudes are reckoned from Greenwich. The sign + means west for longitude and north for latitude. The sign — means east for longitude and south for latitude. G.C.T. signifies Greenwich Civil Time, the 0 hour beginning at midnight and the afternoon hours being numbered from 12 to 23.

I. A Total Eclipse of the Sun, June 8, 1937.

The partial phases of this eclipse will be visible over a large part of the Pacific Ocean, the southwestern part of the United States, Mexico, Central America, the islands of the Caribbean Sea, and the northwestern and western parts of South America. The path of totality starts at sunrise about 1500 miles northeast of the coast of Australia, among the Santa Cruz Islands; thence curves northeasterly over the Ellice and Phoenix groups of islands, between Christmas and Fanning Islands; thence easterly and southeasterly over island-less waters to the coast of Peru, ending at sunset about 400 miles east of Lima.

The chart, Figure 1, shows the limits of the area in which the eclipse may be seen. The broken lines show where the eclipse begins at $18^h\ 30^m$, 19^h, 20^h, and 21^h, and where it will end at 20^h, 21^h, 22^h, and 23^h, Greenwich Civil Time. To obtain local standard time subtract 12^h, 11^h, 10^h, 9^h, 8^h, 7^h, 6^h, or 5^h, according to the standard time zone in which the observer is to be located. If the resulting hour is more than 12 it will be an afternoon hour, so that 12 more should be subtracted to obtain ordinary watch time.

Circumstances of the Eclipse:

	G.C.T. d h m	Longitude from Greenwich ° ′	Latitude ° ′
Eclipse begins	June 8 18 4.4	+178 10	— 7 35
Central eclipse begins	8 19 0.1	—169 44	—11 47
Central ecl. at local app. noon	8 20 40.7	+130 27	+ 9 54
Central eclipse ends	8 22 21.0	+ 70 51	—12 23
Eclipse ends	8 23 16.7	+ 82 56	— 8 11

The duration of totality varies from about 3^m over the Ellice Islands, 4^m near the

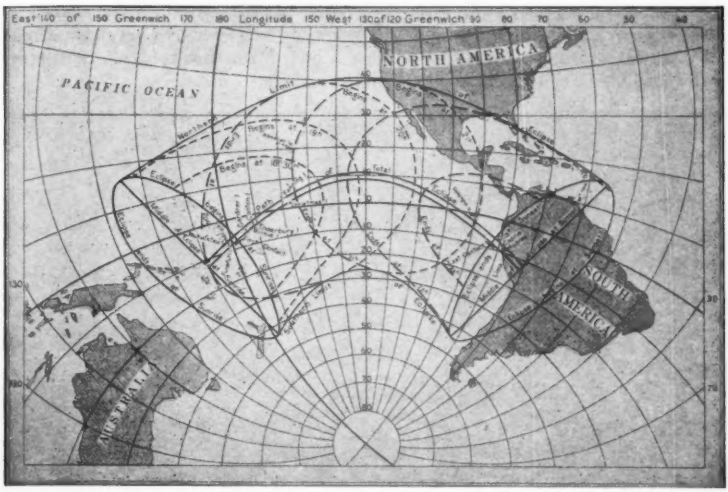

East 140 of 150 Greenwich 170 180 Longitude 150 West 130 of 120 Greenwich 90 80 70 60 50 40
PACIFIC OCEAN
NORTH AMERICA
SOUTH AMERICA
AUSTRALIA

FIGURE 1
TOTAL ECLIPSE OF JUNE 8, 1937.

Phoenix Islands, and 5^m near Christmas Island, to $7^m\ 4^s$ near the middle of the path of total eclipse in longitude $+130°$, then down to about $3^m\ 25^s$ on the coast of Peru, where the sun will be low in the west.

II. A PARTIAL ECLIPSE OF THE MOON, NOVEMBER 18, 1937.

This will be visible at Washington, the beginning visible generally in the extreme northern and northwestern part of Europe, the British Isles, the Arctic Ocean, the North Atlantic Ocean, North and South America, the Pacific Ocean, and northeastern Asia; the ending visible generally in the Arctic Ocean, the North Atlantic Ocean except the eastern part, North America, South America except the eastern part, the Pacific Ocean, eastern Australia, and northeastern and central Asia.

Circumstances of the Eclipse:

	Greenwich Civil Time	d	h	m
Moon enters penumbra	November	18	6	9.1
Moon enters umbra		18	7	37.1
Middle of the eclipse		18	8	18.8
Moon leaves umbra		18	9	0.5
Moon leaves penumbra		18	10	28.7

Magnitude of the eclipse = 0.150 (Moon's diameter = 1.0).

III. AN ANNULAR ECLIPSE OF THE SUN, DECEMBER 2-3, 1937.

This will be visible as a partial eclipse over most of the northern and central parts of the Pacific Ocean, and as far south as —30° on the 170° meridian west from Greenwich; touching also the islands and projecting points of the west, north, and east coasts of the Pacific as far south as Australia on the west and Mexico on the east.

The chart, Figure 2, shows the limits of the regions within which the eclipse may be seen. The broken lines indicate where the partial eclipse begins at $20^h\ 30^m$, 21^h, 22^h, 23^h December 2, and 0^h December 3, and where it ends at 22^h, 23^h December 2, and 0^h, 1^h, and 2^h December 3, Greenwich Civil Time.

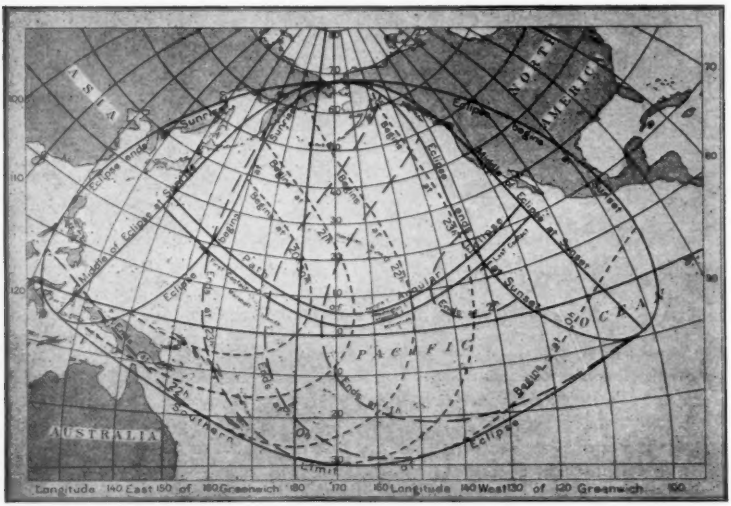


FIGURE 2

ANNULAR ECLIPSE OF DECEMBER 2-3, 1937.

The path of the annular eclipse starts about 700 miles south of Tokyo, Japan, thence runs southeasterly, passing north of the Marshall Islands; thence curves easterly past Christmas Island and northeasterly to a point about 300 miles west from the southern tip of the peninsula of Southern (Baja) California.

The duration of the annular phase varies from about 8^m in longitude —150°, $9^m\ 30^s$ in longitude —170° (north of Marshall Islands), to a maximum of 12^m in longitude +167° (about 600 miles west of Christmas Island), then diminishes gradually to 8^m in longitude +127°.

THE PLANETS.

Mercury begins the year as evening star, about 21° east and 2° north of the sun, seen toward the southwest an hour after sunset. It will be at inferior conjunction with the sun on January 14, reappearing as morning star about February 1, coming out to its greatest elongation west from the sun 25° 41′ by February 7, when it will be easy to see for another week or so. Then the planet will be invisible for about two months because of its circuit behind the sun.

Three and one-seventh such circuits around the sun, as seen from the earth, are made by Mercury each year, with the resulting disappearances of the planet and its alternate reappearances as evening and morning star, visible for a week or two at a time, according to its apparent distance east or west from the sun, as well as to the weather conditions.

The times to look for Mercury this year are given in the following table, the

planet being usually visible for about a week before and after each elongation.

	As Morning Star			As Evening Star	
	Gr. Elong. West	Stellar Mag.		Gr. Elong. East	Stellar Mag.
Feb. 7	25° 41′	+0.2	Apr. 20	20° 2′	+0.4
June 6	24 0	+0.8	Aug. 18	27 25	+0.6
Sept. 30	17 53	0.0	Dec. 12	20 38	−0.3

TRANSIT OF MERCURY.

An interesting phenomenon this year will be a partial transit of Mercury across the sun's disk, which will occur on May 11 between $8^h\ 31^m$ and $9^h\ 30^m$, G.C.T. It is called a partial transit because only part of the disk of Mercury will be projected against the sun's apparent disk, the maximum ingress being 7″.3, while the apparent diameter of Mercury will then be 12″. The transit will thus correspond exactly to a partial eclipse of the sun by the moon, except for the very small size of Mercury's apparent disk.

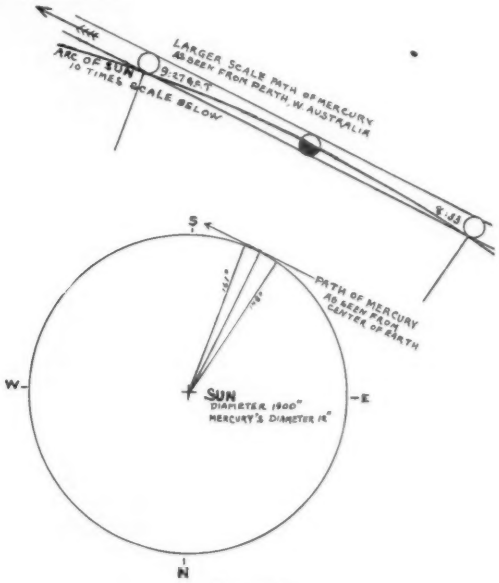


FIGURE 3
PATH OF MERCURY AT TIME OF PARTIAL TRANSIT.

The transit will be visible over Southern Asia, the Philippine Islands, Western Australia, the Indian Ocean, and Central and Southern Africa.

From the center of the earth, or rather from points on the surface in line with Mercury and the center, the transit will hardly be noticeable, since the nearest geocentric approach of the centers of Mercury and the sun on that date will be 15′ 55″.7, while the sum of their semidiameters will be 15′ 55″.8, leaving a maximum ingress of 0″.1.

Elsewhere within the area described above the parallax of Mercury, which

will be nearly double that of the sun on May 11, will throw the planet north and west a little, so that its disk will project partially upon the disk of the sun.

It requires the use of a telescope to show even the full disk of Mercury against that of the sun, so the diagram, Figure 3, has been drawn to give the telescopic view for northern observers, with S at the top of the circle. For southern observers the diagram should be inverted, or turned to any convenient position.

In the upper part of the diagram I have drawn a short arc of the sun's disk on 10 times the scale of the circle below, in order to show the extent of the transit as seen from Perth, W. Australia.

The sun and Mercury will be near the zenith in the southern part of Arabia at the time of the transit.

The following data are given in the *American Ephemeris* concerning the local circumstances of the transit for some of the principal cities within the area of possible observation.

LOCAL CIRCUMSTANCES OF THE TRANSIT OF MERCURY, MAY 11, 1937.

	Ingress			Egress		
	G.C.T. External Contact	—Angle from— North Point	Vertex	G.C.T. External Contact	—Angle from— North Point	Vertex
	h m	°	°	h m	°	°
Bombay, India	8 48	151	67	9 12	157	73
Cape of Good Hope, S.A.	8 41	149	301	9 24	159	318
Hong Kong, China	8 47	151	77	9 11	157	83
Johannesburg, S. Africa	8 41	149	304	9 23	159	327
Madras, India	8 44	150	56	9 16	158	67
Manila, P. I.	8 43	150	69	9 14	158	79
Mauritius (Port Louis)	8 38	149	341	9 25	160	8
Perth, W. Australia	8 33	148	19	9 27	161	37

The last transit of Mercury occurred on November 8, 1927; the next will occur on November 12, 1940.

Venus is rapidly coming around from the farther side of its orbit and will be a brilliant "evening star" in the west for three months. Its greatest elongation east from the sun, 46° 50′, will be reached on February 5, when its stellar magnitude will be —4.0. It will reach its greatest brilliancy on March 12, when its stellar magnitude will be —4.3, about 12 times as bright as Sirius, the brightest of all stars.

Venus will be lost to sight for a few days on either side of April 18 when the planet passes between the earth and sun and is hidden by the brightness of the latter. On May 24 it will be at greatest brilliancy as "morning star," the stellar magnitude being then —4.2, almost as bright as in March. It will reach greatest elongation, west from the sun 45° 45′, on June 27, when it will have finished a great loop in the constellations Aries and Pisces and taken up a regular eastern course again for the remainder of the year. Its brightness will diminish very gradually, becoming constant at —3.4 for the last three months of the year, although approaching superior conjunction with the sun and being submerged in the morning dawn at the end of December.

There will be an occultation of Venus on August 3 which will be visible in the eastern part of the United States. The times of the occultation at Washington will be: Immersion $2^h\,13^m.2$, emersion $2^h\,42^m.3$ A.M., Eastern Standard Time. In New England the corresponding times will be about $2^h\,13^m.4$ and $2^h\,48^m.9$ A.M., Eastern Standard Time.

Mars starts the year in the constellation Virgo, about 5° northeast of the star

Spica, and will move eastward along the ecliptic until April 14, then westward until June 27, then eastward again until the end of the year, when it will be in the constellation Aquarius. The planet will be at opposition to the sun on May 19, and therefore in best position for observation during the spring and summer months. It will be at quadrature 90° west from the sun on February 4, and at quadrature 90° east from the sun on September 10. It will be nearest to the earth on May 28, when its distance will be about 47,000,000 miles, and its apparent diameter 18″.4. At the beginning and end of the year the distance of Mars from the earth will be about 154,000,000 miles and its apparent diameter less than 6″. On account of the southern declination of the planet, observers on the southern hemisphere of the earth will have the most favorable conditions for studying the surface markings of Mars this year.

The stellar magnitude of Mars will vary from +1.4 on January 1 to —1.8 during the latter half of May, then back to +1.1 at the end of the year. When at its brightest the planet will be situated about midway between the two +1.2 magnitude stars Antares (α Orionis) and Spica (α Virginis), but about 7.5 times as bright as those stars, which it approximately equals at the beginning and end of the year.

There will be occultations of Mars by the moon on May 24, June 20, and July 17. The first of these should be visible in the south Indian Ocean and parts of Australia; the second in Australia and the islands north and east of Australia; the third in the eastern part of the United States, the northwestern part of Africa and parts of the Atlantic Ocean.

Jupiter begins its course for the year in the constellation Sagittarius, proceeds eastward close to the ecliptic until May 15, then westward until September 13, then eastward for the rest of the year, ending in Capricornus south of the stars α and β of that constellation. The planet will be at quadrature 90° west of the sun April 16, at opposition July 15, and at quadrature 90° east of the sun October 12. The best time for observing the surface markings on the planet will be in the summer and autumn for northern observers. Its southern declination, however, will favor those in the southern hemisphere.

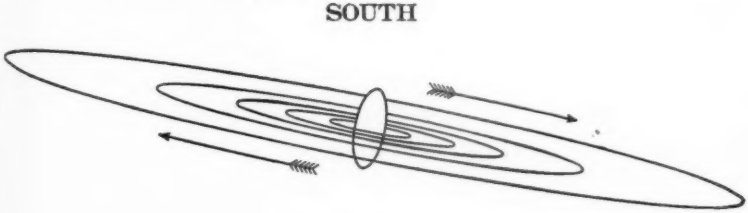


FIGURE 4

The stellar magnitude of Jupiter will be —1.4 in January, —2.3 during the month including opposition, and —1.6 (just the brightness of Sirius) in December. Jupiter will be about 32″ in January, 47″ in July, and 33″ in December.

The diagram, Figure 4, shows the orbits of the five inner satellites of Jupiter, the vertical scale of the diagram as drawn being 3 times the horizontal scale in order to separate the inner orbits distinctly. The planet is really flattened at the poles instead of being elongated up and down as drawn.

The innermost satellite, numbered V because it was discovered after the others, is too faint to be seen with a small telescope. Satellites I, II, III, and IV (in the 2nd, 3rd, 4th, and 5th orbits outward from the planet) are all bright even with a small telescope, and their changing configurations from day to day are interesting to watch.

As the planet rotates in about 10 hours the aspect of the belts and other colored markings, light and dark, varies from hour to hour and is a never-ending source of delightful study to the amateur. The apparent equatorial diameter of Jupiter will be about 32″ in January, 47″ in July, and 33″ in December.

Saturn will follow a path about 12° long, just below the ecliptic in the constellation Pisces, moving eastward until July 18, then westward until December 2, then eastward. It will be in conjunction with the sun on March 16, at quadrature 90° west of the sun June 26, at opposition September 25, and at quadrature 90° east of the sun December 20. The best time for observing Saturn will be during the latter half of the year.

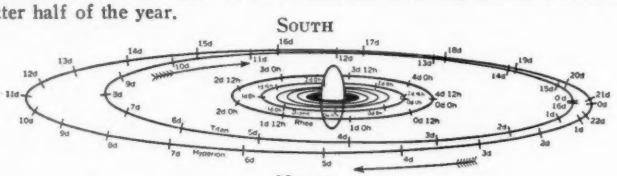


FIGURE 5

The diagram, Figure 5, shows the relative positions of the rings and the orbits of the seven inner satellites of Saturn at the date of opposition, September 25. In this diagram, as in the corresponding one for Jupiter, the crosswise scale of the orbits as drawn is 3 times the lengthwise scale. The rings of Saturn will not be opened up enough to afford very satisfactory views of them this year.

The stellar magnitude of Saturn will be +1.4 in January, +0.7 in September, and +1.2 in December, making it brighter than any of the stars in the vicinity of the planet. Fomalhaut (α Piscis Australis), magnitude +1.3, 30° to the south and 15° to the west, will be its nearest rival among the stars.

Uranus will move back and forth close to the ecliptic in the region about midway between the stars α Arietis and α Ceti, making a net advance eastward of about 4° during the year. It will be at quadrature 90° east of the sun January 26, in conjunction behind the sun April 30, at quadrature 90° west of the sun August 6 and at opposition November 4. The winter months at the beginning and end of the year will be the most favorable for observation of this planet. Its stellar magnitude at opposition will be 6.0. The four satellites are very faint, so we do not reproduce the diagram of their orbits.

Neptune will be at opposition on March 8, so that it will be in most convenient position for observation in the spring months. It will then be about 6° west and 4° north of the star β Virginis, close to the line joining that star to Regulus (α Leonis). The planet will be at quadrature 90° east of the sun June 7, in conjunction September 11, and at quadrature 90° west from the sun December 13. The stellar magnitude of Neptune at opposition will be 7.7.

Pluto is in the region about 6° southeast of the star Pollux (β Geminorum) and about 1° north of μ Cancri. At the end of the year it will be about midway between the stars μ and λ Cancri. It is too faint to be seen with a small telescope.

Planet Notes for February, 1937

By CLIFFORD E. SMITH

Note: All times, unless otherwise stated, are Central Standard Time.

The *Sun* will be moving with an apparent northeasterly motion from the central part of Capricornus to the central part of Aquarius. Its distance from the earth, at the beginning of the month, will be about 91.5 million miles, and this distance will increase about a half million miles during the period. The position of the sun on the first and last days of the month will be R.A. $20^h\ 57^m$, Decl. —17° 17′ and R.A. $22^h\ 42^m$, Decl. —8° 12′.

The phenomena of the *Moon* will occur as follows:

Last Quarter	Feb.	3	at 6	A.M.
Full Moon		11	" 2	A.M.
First Quarter		17	" 10	P.M.
Full Moon		25	" 2	A.M.
Apogee		3	" 6	A.M.
Perigee		15	" 2	P.M.

Mercury will be a morning object. Its motion among the stars will be from central Sagittarius to the eastern part of Capricornus. During the first part of the month it will rise about an hour and a half before the sun. Greatest elongation west will occur on February 7 at 8:00 A.M. (25° 41′). Conjunction with the moon will occur on February 9 at 1:00 A.M. (Mercury 2°.4 S). The position of Mercury on the first and last days of the month will be R.A. $19^h\ 14^m$, Decl. —20° 32′ and R.A. $21^h\ 30^m$, Decl. —16° 44′. The distance from the earth will be about 80 million miles at the beginning of the month, and this distance will increase to about 116 million miles by the end of the month. The corresponding change in apparent diameter will be from about 7.6 to about 5.3 seconds of arc.

Venus will be an evening object in Pisces. Its apparent motion among the stars will be easterly, and it will set about three hours after the sun. The distance from Venus to the earth will be about 68 million miles at the beginning of the month and about 50 million miles at the end of the month. The corresponding apparent diameter will be 23 and 32 seconds of arc. Greatest elongation east will occur on February 5 at 2:00 A.M. (46° 50′). Conjunction with the moon will occur on February 14 at 5:00 P.M. (Venus 2°.9 S).

Mars will be a morning object in Libra. During the first part of the month it will rise about midnight since quadrature west will occur on February 4 at 2:00 A.M. The distance from the earth to Mars will decrease from about 125 to about 100 million miles, and the apparent diameter will increase from about 7 to about 8.8 seconds of arc. Conjunction with the moon will occur on February 3 at 10:00 A.M. (Mars 4°.8 N). Its apparent motion among the stars will be easterly.

Jupiter will be a morning object in Sagittarius, and, during the middle of the month, it will rise about two and one-half hours before the sun. Its distance from the earth will be about 560 million miles, and its apparent diameter will be about 31 seconds of arc. Conjunction with the moon will occur on February 8 at 7:00 A.M. (Jupiter 2°.0 S).

Saturn will be too near the sun in apparent position to be of much general interest during this period. During the middle of the month it will set about two hours after the sun. Thus it will be an early evening object, and it will be in the

constellation of Pisces. Its distance from the earth will be about 975 million miles, and its apparent diameter will be about 14 seconds of arc. On February 13 at 9:00 A.M., conjunction with the moon will occur (Saturn 7°.7 S).

Uranus will be an evening object in southeastern Aries, and, during the first part of the month, it will set about an hour before midnight local time. Its distance from the earth will be about 1870 million miles, and its apparent diameter will be about 3.4 seconds of arc. Conjunction with the moon will occur on February 16 at 9:00 A.M. (Uranus 4°.2 S). The position of Uranus on February 15 will be R.A. $2^h\ 16^m$, Decl. $+13°\ 8'$.

Neptune will be above the horizon most of the night hours, since opposition will occur early in March. It will be about midway between the stars χ and τ in the constellation of Leo. Its distance from the earth will be about 2700 million miles and its apparent diameter will be about 2.5 seconds of arc. Conjunction with the moon will occur on February 26 at 4:00 A.M. (Neptune 6°.6 N). Its position on February 15 will be R.A. $11^h\ 18^m$, Decl. $+5°\ 40'$.

OCCULTATION PREDICTIONS

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result, in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.

Date 1937	Star	Mag.	IMMERSION Greenwich C.T. h m	*a* m	*b* m	Angle E from N °	EMERSION Greenwich C.T. h m	*a* m	*b* m	Angle E from N °
Feb. 6	39 Oph	5.4	9 32.1	−0.7	+0.5	124	10 41.9	−1.8	+1.4	250
19	τ Tau	4.3	0 41.5	−1.9	+0.6	65	1 51.4	−1.3	−2.0	296
19	175 H¹ Tau	6.5	23 44.1	−1.9	−1.0	119	0 59.0	−2.0	+0.7	249
24	*L* Leo	5.3	3 5.6	−2.2	+0.6	89	4 14.5	−1.0	−2.3	332

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′.

Feb. 19	τ Tau	4.3	0 3.7	−1.9	+1.2	71	1 23.9	−2.0	−0.7	279
19	175 H¹ Tau	6.5	23 10.7	−1.8	−0.2	118	0 19.3	−1.6	+2.0	239
24	*h* Leo	5.3	2 32.7	−1.4	+0.1	115	3 51.6	−1.6	−0.5	299
28	370 B.Vir	6.0	11 51.6	−1.1	−1.8	118	13 3.2	−0.7	−1.8	284

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.

Feb. 2	BD—16°3785	6.5	14 11.3	−2.5	−0.4	88	15 36.7	−1.8	−2.2	314
6	191 B.Oph	6.3	12 41.0	−0.4	−0.4	138	13 40.2	−2.1	+2.1	236
6	44 Oph	4.3	13 15.8	−1.3	+0.5	110	14 37.8	−2.1	+0.9	260
20	141 Tau	6.3	9 12.0	−0.8	−0.1	56	9 50.4	+0.7	−2.5	330
22	5 Cnc	5.9	11 43.6	+1.0	−3.4	176	12 6.0	+0.5	+0.4	226
24	*h* Leo	5.3	2 7.0	−0.5	−0.4	134	3 7.6	−0.9	+1.3	266
28	370 B.Vir	6.0	11 17.0	−1.4	−2.2	151	12 31.6	−2.2	−1.0	269
28	BD—11°3398	6.5	13 44.7	−1.0	−3.4	168	14 27.1	−1.1	−0.2	237

Variable Star Notes from the American Association of Variable Star Observers

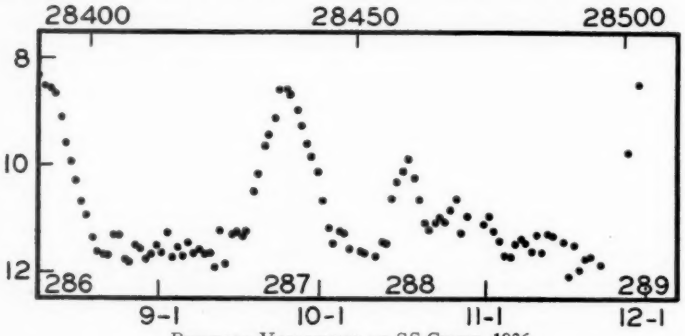
By LEON CAMPBELL, Recorder

New Observers and Observations: Messrs. Paul C. Atchison of Abilene, Texas, and William A. MacCalla, of Pittsburgh, Pennsylvania, and the Class in Astronomy at Vassar College have contributed for the first time to the work of the A.A.V.S.O. The following list contains the names of observers whose observations were received during the month of November. Eighty-two members have contributed nearly five thousand observations.

Name	Vars.	Observations	Name	Vars.	Observations
Ancarani	11	22	Koons	14	17
Ashbrook	4	10	Kotsakis	4	32
Atchison	1	1	La Fon	20	20
Ballhaussen, Miss	14	20	Lewis	35	41
Blunck	44	75	Loreta	103	241
Bouton	73	116	MacCalla	5	8
Brocchi	30	93	Marshall	4	67
Brown, S. C.	9	9	McLeod	14	14
Buckstaff	12	25	Meek	75	335
Callum	32	77	Millard	16	26
Cameron	8	14	Mitchell, R. A.	17	43
Campbell	1	6	Monnig	6	21
Chandra	177	298	Murphy	8	32
Chartier	12	18	Peck	10	31
Christman	65	68	Peeling	1	1
Cilley	79	154	Peltier	184	214
Dafter, Mrs.	8	28	Perkinson	5	15
Ellis	49	93	Plakidis	7	16
Ensor	73	121	Purdy	5	7
Fairbanks	15	16	Recinsky	10	26
Fish	3	3	Reed, D. S.	1	17
Gregory	34	36	Rosebrugh	36	154
Haas, W.	12	63	Roth	2	2
Haiss	1	1	de Roy	10	78
Hamilton	6	26	Ryder	5	11
Hartmann	156	337	Scanlon	31	32
Herbig	82	227	Schattle	8	92
Hiett	14	45	Schmidt, R.	5	8
Hildner	8	15	Scranton	5	7
Hildom, A.	12	18	Shultz, Miss	16	16
Holt	28	30	Sill	44	67
Houghton	64	166	Smith, F. P.	29	48
Howarth	8	8	Smith, F. W.	1	3
Humbert	4	7	Smith, J. R.	16	16
Jensen	7	9	Strelitzer	1	1
Jones	130	446	Thomas, Mrs.	1	3
Kanda	3	46	Thorndike	2	3
Kempinski	5	5	Thorne	3	3
Kirkpatrick	24	136	Vassar College	6	28
Kitchens	4	4	Webb	40	56
Knott	6	22			
de Kock	43	187	82		4950

Peculiar Variations of SS-Cygni: The behavior of SS Cygni since the maximum of September 24 has been decidedly erratic. After the star had reached minimum, it remained there for a short time only, rising to the tenth magnitude

again on October 17, when it was observed simultaneously by several A.A.V.S.O. observers then holding a meeting at Harvard. Instead of dropping immediately to normal minimum, around the twelfth magnitude, the star remained at, or near, magnitude eleven for nearly ten days, and with well-observed oscillations dropped to the twelfth magnitude about November 17. At the end of November it was again on the rise to maximum, according to observers at the Whitin Observatory, Wellesley College. Such erratic behavior was last observed in this star in October, 1933, and from January to March, 1934. The accompanying figure illustrates the peculiar variations which occurred between maxima 286 and 289.



PECULIAR VARIATIONS OF SS CYGNI, 1936

Recently Observed Minimum of T Orionis: T Orionis, 0530o5a, involved in the giant Orion Nebula, has recently passed through a conspicuously faint and well-observed minimum. Around October 13 it was estimated by various observers as of magnitude 9.8, a week later it was observed at magnitude 11.5, and on November 8 it had attained normal maximum, magnitude 9.7. The decrease in light was decidedly more rapid than the increase. Such sudden and short-lived minima are not unprecedented in stars so involved in nebulosity as is this well-known variable star. We have similar peculiarities manifested by R and S Coronae Australis, which are known to be associated with gaseous material, and it is of great importance that such minima, when they occur, be closely observed. Previously published annual light curves of T Orionis are to be found in Harvard Circulars on the Light Curves of Peculiar Variables, appearing since 1926. S Orionis, 0524o4, with a period of about 410 days, is the only other well-known variable star situated in the Orion Nebula which can be said to have a regular period of variation and even this long-period variable presents anomalies at maximum light.

New Bright Variable in Telescopium: Mr. Mark Howarth, of Newcastle, New South Wales, calls attention to the variation of a star in the constellation of Telescopium, situated at $18^h\ 58^m9$, $-51°\ 34'$ (1900). This star is $-51°11917$ in the Cordoba Durchmusterung, and was measured as of magnitude 7.33 in the Harvard Photometry. The star was originally found to be variable by Dr. W. J. Luyten, at the University of Minnesota, in his systematic blinking of star images on Harvard plates for the detection of stars of large proper motion. He reported a variation between magnitudes seven and nine but gave no other information. Mr. Howarth noted the star around the seventh magnitude in August of this year. A photograph taken by him on October 12 shows a diminution in light to about the

ninth magnitude and his visual observations, made late in October, place the star at 10.2 to 10.4. An examination of Harvard plates shows the variable to have been faint in the years 1913 and 1919, evidently at minima of several weeks duration. This star should be followed by southern observers in order to ascertain the type of variation.

Recently Named Variable Stars: The thirty-fourth list of variables, with names recently assigned by the Astronomische Gesellschaft Committee, contains 193 stars; 32 per cent of these are from Harvard plates, 29 per cent from Johannesburg plates, 25 per cent from Sonneberg plates, and 7 per cent from Riverview College plates.

The list includes fifty long-period variables or 26 per cent of all; forty-one Algols, or 21 per cent; thirty-seven RR Lyrae type variables, or 19 per cent; sixteen, or 8 per cent, of Cepheids; and four novae. Thirteen variables are classified as of the W Ursae Majoris type, two as resembling U Geminorum, and four as similar to RV Tauri. Since the W Ursae Majoris, Algol, and Beta Lyrae types of variation all belong to the eclipsing class, there are sixty-five, or 33 per cent of the whole, which belong to this group. Of the 193 variables only three—Nova Lacertae and two stars found to be variable by Stebbins with a photoelectric photometer—can be considered as visual discoveries. Two novae in Scorpio were discovered photographically by Miss H. H. Swope, one appearing bright in May, 1893, and the other in September, 1901. A third nova was discovered photographically by Ghent and was observed only on the descending branch of the light curve in April, 1907. The fourth nova is the well-known Nova Lacertae, first found by Mr. K. Gomi, on June 18, 1936.

Photoelectric Photometry of Asteroids: A vigorous attack on the variability of bright asteroids has been made by Dr. W. A. Calder, with his highly sensitive photoelectric cell. The preliminary results for Ceres, Juno, Pallas, and Vesta are given in a recent *Harvard Bulletin*. For Ceres, there is found to be a definite rotational period of three hours and thirty-six minutes, or 0.15 day, with a range of about 0.03 magnitude. Although the suspected variation of Pallas is of the order of 0.04 magnitude, the observations are insufficient to determine any rotational period. For Juno, not enough material is as yet available from which to draw any conclusions. Vesta shows a variation amounting to 0.06 magnitude between May 8 and 21, 1934.

The Variable XY Persei: Miss C. D. Boyd at Harvard finds that the variable XY Persei, 034238, presents an exceedingly peculiar light curve. While at first glance the plotted curve has some resemblance to that of R Coronae Borealis, this possibility is precluded by the small range and the spectrum of the star, which is a close double. She thinks it is possible that we are dealing with two Algol variables whose different minima so coincide as to cause a diminution of combined light of only one and one-half magnitudes.

Forty-two New Variable Stars in Milky Way Field 132: Noah W. McLeod, an A.A.V.S.O. observer located at Christine, North Dakota, has investigated a Milky Way field situated at $10^h\,09^m$, $-13°.2$. On eighty-five Harvard plates he has found forty-two stars which are certainly variable. Twenty-one of these were previously known. The remaining twenty-one appear to resemble those found in other Milky Way fields, in that they have small ranges, between 0.5 and 1.3 magnitudes. Few long-period variables are found in this region, which includes portions of the constellations of Monoceros and Canis Major. Long-period variables usually possess a much greater range of variation than are found for these stars.

Dimensions and Parallaxes of Novae: A recent discussion by Dr. D. F. McLaughlin, on "Dimensions and Parallaxes of Novae," affords an interesting comparison with similar determinations by Dr. S. I. Gaposchkin in 1935 for the same bright novae. McLaughlin bases his determination on the radial velocities, spectral types, and actually observed portions of the rising branches of the light curves. Gaposchkin's discussion is based on the radial velocities, times of rise, total observed luminosities, and surface brightness. McLaughlin assumes that the observed radial velocity represents the rate of expansion; that the effective temperature of the photosphere of such stars ought to be inferred from the type of absorption spectrum given by the nova; and that the luminosity of a nova at, and before, maximum is determined by the radius and effective temperature of the photosphere, as in a normal star. Using two hypotheses, based on (a) the velocity integrated over the entire disc of the star, and (b) the radial velocity as observed, he derives for the six novae under discussion parallaxes, absolute magnitudes, and radii at maximum. McLaughlin's deduced parallaxes and absolute magnitudes are not widely at variance with those based on stellar line intensities of calcium.

		Parallax			Absolute Magnitude			Radius at Maximum		
		McL(a)	(b)	S.G.	McL(a)	(b)	S.G.	McL(a)	(b)	S.G.
								$\odot$	$\odot$	$\odot$
N Per	1901	0".0009	0".0013	0".0021	— 9.9	— 9.2	— 8.4	278	199	144
N Gem	1912	0.00013	0.00019	0.0012	—10.8	—10.0	— 5.9	540	376	54
N Aql	1918	0.0012	0.0017	0.0016	—10.7	— 9.9	—11.4	508	363	534
N Cyg	1920	0.00027	0.00038	0.0009	—10.8	—10.1	— 8.8	540	384	264
N Pic	1925	0.0012	0.0017	0.0017	— 8.3	— 7.6	— 7.7	359	256	289
N Her	1934	0.0016	0.0022	0.0006	— 7.7	— 7.0	— 9.8	276	198	402

The accompanying table gives the quantities as derived by McLaughlin and Gaposchkin. Mean absolute magnitudes for the six novae are McL (a) —9.7, Mc (b) —9.0, and S.G. —8.7, with a spread of 3.1, 3.1, and 5.5, respectively. Mean radii at maximum light, in terms of the sun's radius, are McL (a) 417, McL (b) 296, and S.G. 281, with a spread of 264, 186, and 480, respectively. The greatest divergence is in the radius at maximum of Nova Geminorum, in which Gaposchkin deduced a value of 54 times the radius of the sun as against 540 or 376 by McLaughlin's two hypotheses. McLaughlin estimates Nova Persei 2.0 or 1.4 times larger than does Gaposchkin, while for Nova Herculis, McLaughlin gives the radii as 0.7 or 0.5 that derived by Gaposchkin.

Gaposchkin considers that the novae in their initial stages are nearer to the white dwarfs in luminosity and radius than to any other type of star.

December 12, 1936.

Comet Notes

By G. VAN BIESBROECK

Not since last September have any new comets been announced. Those that had been discovered earlier in the year are now all too faint so that no known comets are observable at this time. Only Comet 1935 *d* (Van Biesbroeck) will for some time remain in reach of powerful telescopes. Jeffers at the Lick Observatory observed it on October 7, and on a recent very transparent night (Dec. 14) I recorded its 17^{M} image with the 24-inch reflector of the Yerkes Observatory. This extends the period of observation to seventeen months since the discovery in the summer of 1935.

The recovery of PERIODIC COMET D'ARREST, which is expected at perihelion in January, 1937, becomes very doubtful. The object has not been found near the ephemeris position (p. 495). It is probably quite faint, the prediction is none too certain, and the region is visible for only a short time after sunset. This makes it an almost hopeless case.

For the year 1937 the *Handbook of the British Astronomical Association* lists the return of four periodic comets. Two of these, namely, ENCKE and GRIGG-SKJELLERUP, have reliable orbits. The former makes a favorable apparition at the end of the year. The latter, having the short period of very nearly five years, will almost repeat its course of 1932 so that recovery is due this spring. The following ephemeris (*loc. cit.*, p. 32) by P. Y. Harris and W. P. Henderson shows that the search may be started before long.

EPHEMERIS OF PERIODIC COMET GRIGG-SKJELLERUP.

1937	α	δ	Distance from sun	Distance from earth
	h m	° ′		
Jan. 3	6 28.5	−6 56	1.996	1.085
11	6 15.5	7 53	1.923	1.032
19	6 2.7	8 26	1.850	0.993
27	5 50.4	8 32	1.775	0.966
Feb. 4	5 40.2	8 12	1.699	0.949
12	5 32.7	7 30	1.623	0.939
20	5 28.2	6 31	1.546	0.931
28	5 27.1	5 18	1.470	0.924
Mar. 8	5 29.1	3 56	1.394	0.914
16	5 34.3	2 27	1.318	0.899
24	5 42.5	−0 53	1.245	0.878

This course lies across the constellation of Orion. The decreasing distances make it probable that the comet will be in reach before the end of this ephemeris.

The prediction for the third periodic comet, namely TUTTLE-GIACOBINI, is much more problematic. The ephemeris is continued here from p. 573 of the December issue.

EPHEMERIS OF PERIODIC COMET TUTTLE-GIACOBINI.

1937	T assumed 1937 Jan. 31.0 α	T assumed 1937 Jan. 31.0 δ	T assumed 1937 Feb. 16.0 α	T assumed 1937 Feb. 16.0 δ
	h m	° ′	h m	° ′
Jan. 3	14 43.1	−13 27	13 54.6	−12 39
7	15 0.8	13 58	14 11.8	13 17
11	15 18.4	14 21	14 29.4	13 48
15	15 36.2	14 38	14 47.3	14 14
19	15 54.0	14 48	15 5.5	14 33
23	16 11.4	14 54	15 23.9	14 46
27	16 28.7	14 56	15 42.3	14 52
31	16 46.1	14 47	16 0.7	14 51
Feb. 4	17 2.9	14 34	16 19.2	14 41
8	17 19.4	14 17	16 36.8	14 28
12	17 35.6	13 55	16 54.4	14 7
16	17 51.2	13 29	17 11.9	13 40
20	18 6.4	12 58	17 28.5	13 8
24	18 21.1	12 24	17 44.9	12 31
28	18 35.3	−11 48	18 0.7	−11 51

The fourth comet expected this year is the first return of COMET 1927 VI (GALE) which comes in reach towards the end of the year.

To these four objects we should add PERIODIC COMET 1925 II (SCHWASSMANN-WACHMANN), the faint object describing an ellipse of small eccentricity in sixteen years, which has attracted attention by its surprising changes in brightness. It

will be of interest to watch it this spring although the southern declination this year will make this a less favorable opposition for northern stations. The following ephemeris by J. C. Behrens shows that the comet will move slowly in the southern part of the Constellation Virgo.

EPHEMERIS FOR COMET 1925 II (SCHWASSMANN-WACHMANN).

1937		α h m	δ ° ′
Jan.	0	13 56.2	—20 36
	10	14 0.0	21 11
	20	14 3.1	21 42
	30	14 5.3	22 10
Feb.	9	14 6.5	22 33
	19	14 6.7	22 51
Mar.	1	14 5.8	23 3
	11	14 3.9	—23 10

Williams Bay, Wisconsin. December 19, 1936.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

Just too late for inclusion last month a set of observations on the Orionids arrived from Professor Mohd. A. R. Khan of Begumpet, India. A summary of these is given below. I am not quite sure from the context of his letter whether his numbers refer only to Orionids, or to all meteors, though they probably refer to all. He states that the radiant (for the four nights?) was at R.A. 93° 45′, Decl. +14°. On all nights an unusual proportion of the meteors were bright, some being very brilliant. His report fully confirms my previous deduction that 1936 gave a strong maximum of the Orionids.

Date 1936	Began U.T.	Ended U.T.	Total	Meteors	Fac.	Rate	Cor. Rate
Oct. 18	20:30	21:00	30	8	0.7	16	23
	21:30	22:00	30	14	0.7	28	40
Oct. 19	22:30	23:00	30	6	0.3?	12	?
	23:00	23:30	30	26	1.0	52	52
	23:30	23:50[1]	20	9	0.7?	27	?
20	20:30	21:30	60	37	.	37	.
21	23:05	23:45	40	24	0.7	36	51

Khan also reports a grand fireball having passed over Hyderabad on October 13 at 7:33 P.M. (Indian Standard Time). As seen from Begumpet it started at R.A. 23h 05m, Decl. +10° and ended behind a cloud at about R.A. 19h, Decl —30°. It remained visible for three or four seconds, and one second after starting it grew to the brightness of the full moon, giving a bluish green light. Professor Khan heard the sound of the explosion seven minutes later. He has made a search for fragments, but, having no other certain observations, he has been unable to identify the exact end point. From the general description, there is a strong probability that fragments reached the ground.

Our regional director in Florida, Dr. J. H. Kusner, reports by letter an extensive campaign for heights during the Orionid epoch, but no details have yet

[1] Dawn at end.

been received. The little additional information on the Leonids from various stations shows that they were few in number. H. Inouye at Nagoya, Japan, observing on November 11-12, 15^h to 16^h, F = 1.0, saw 8 meteors, 4 being Leonids. C. H. Smith of Waterloo, New York, tried to observe on several nights, but clouds prevented work except for about an hour on November 16-17. Even this period was hazy, and few meteors were seen. F. W. Smith, observing at Vineland, New Jersey, on November 17-18, 11:00 to 12:35, F = 1.0, saw 8 meteors, none being a Leonid.

I have just received two most interesting papers from Professor Cuno Hoffmeister of Sonneberg, Germany, the meteor authority of that country. These he requests me to have printed in some American journal. As I am most desirous of having our A.M.S. members read and profit by the paper on the great fireball of 1936 July 23, I am shortening my own part of these Notes and devoting the latter part to Professor Hoffmeister's paper. He, indeed, needs no introduction in these pages: many of our members have for the past two years been actively engaged upon the meteor observing program, generally known by the joint name Hoffmeister-Olivier, which is designed to collect data for further researches into the problem of daily and annual variation on which Hoffmeister is the world authority. Already we have been able to turn over many thousands of observations to him, and he is now engaged upon their reduction. We expect 1936 to bring large additions to the records already available, and the next year or two will probably see his conclusions ready for publication. To the many observers taking part, the following paper will be all the more interesting as an example of the excellent results obtained by Hoffmeister from data furnished him by others.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1936 December 17.

The Meteor of July 23, 1936

By C. HOFFMEISTER.

A very remarkable meteor was observed in Europe—Germany, Czechoslovakia, Austria, and Switzerland—on the night 1936 July 23-24 at $23^h\,0^m1$ U.T. It deserves attention not only for its long enduring train but also for its exceptionally low heliocentric velocity and unusual cosmic relationship. About 500 observations have been collected, and amongst them there are many which give the coördinates of the apparent path. Also a part of the path was photographed at Sonneberg with the Zeiss Triplet 170/1200 mm. From these observations the author has been able to compute the real path with great exactness. The results are given in the following table:

Radiant	$\alpha =$ 21°.41 ± 0°.03 m.e.	
	$\delta = +30.83 \pm 1.78$ m.e.	
Beginning of path	$\lambda = 13°\ 20'$ east of Greenwich	
	$\phi = +51°\ 32'.5$	H = 129 km
End of path	$\lambda = 11°\ 54'$ east of Greenwich	$\phi = +51°\ 18'$
	H = 72.6 km ± 1.5 km m.e.	
Length of path	117.3 km	
Azimuth of Radiant at the end point	254° 21' (N 74° 21' E)	
Angle with the horizon at the end point	27° 44'	
Geocentric velocity	39.0 km/sec	
Geocentric velocity, corrected	37.36 km/sec	
Corrected Radiant	$\alpha = 22°.6$	$\delta = +29°.8$
	$\lambda = 32.1$	$\beta = +18.8$
Heliocentric velocity	13.5 km/sec	
Distance of app. Radiant from the Apex	18°.9	
Solar longitude	120° 51'	

The possibility that the radiant and velocity might be erroneous by such amounts that the character of the heliocentric orbit could be totally changed has been carefully examined. As to the radiant this alternative must be rejected. The velocity on the contrary could not be determined with the same degree of exactness. But even a very improbable error of the duration could not suffice to increase the velocity so that the meteor might be assigned to the group of cometary meteors. The heliocentric orbit of the meteor may be characterized by the following data:

Semi-major axis	$a = 0.559$
Ascending node	$\Omega = 120° 51'$
Time of revolution	$U = 0.42$ years
Inclination	$i = 116° 34'$
Eccentricity	$e = 0.785$
Perihelion distance	$q = 0.120$

The collision with the earth occurred near aphelion.

It is interesting that a very similar meteor was described many years ago by Dr. Grundmann. It is the meteor of August 3, 1908, which not only had a similarly low heliocentric velocity of 19.5 km/sec, but also resembled the meteor described here in every respect—train, height, and light curve. The meteor of July 23, 1936, however, was much brighter, and the train lasted much longer.

There can be little doubt that these meteors belong to a class of celestial bodies previously unknown. The author is inclined to propose the name of *Planetary Meteors* for this group, thus indicating their stronger relationship to the planetary system in comparison with the other groups of Cometary and Interstellar Meteors. Whether there is some relationship between these meteors and the reflecting matter of the Zodiacal Light cannot be decided at present.

The meteor was extremely bright. From estimates between -13^M and -15^M at a distance of about 150 km, an absolute brightness of about 10,000 millions of candle powers can be computed. The color was yellow at first sight, bluish-white at greatest brightness, and reddish or yellowish at the end. The meteor faded away without final explosion, the most violent outbursts being observed in the third quarter of the path.

The train was unusually bright during the first minute of its visibility; the color was red in the center, bluish white at the edges. A surprising fact, probably never observed before, was that the train rose for about 3.3 km during the first 86 seconds in a nearly vertical direction, at a rate of 38 meters a second. Probably this phenomenon was due to thermic ascending of the hot gas; the train came to rest at the same time at which the red color of the inner part of the train disappeared. In the ensuing time, i.e., from $23^h 2^m$ U.T. to the end of visibility, no thermic luminescence but only recombination luminescence may have been active. The decrease of brightness of the train was very fast at the beginning and extremely slow towards the end of visibility. The luminous matter of the train expanded at a rate of about four meters a second as determined by estimations of the apparent diameter and by a photograph taken at Sonneberg five minutes after the meteor had appeared. The meteor had moved from about ENE with 28° inclination. The deformation of the train began immediately afterwards. The middle part rose and drifted with the higher eastern part towards north, while the lower western part drifted towards east. About 10 minutes after the appearance the train formed approximately a semi-circle of some 15 km diameter, the convex side directed towards northwest, the northeastern end being the higher one. As seen from NE it appeared nearly in its real shape, while from SW it showed the form

of an acute angle. The lower part faded first, and twenty minutes after the appearance a diffuse cloud remained, drifting slowly towards NE. Its position was independently determined from three good observations at $23^h\ 20^m$ U.T., giving the coördinates

$$\lambda = 12°\ 34' \qquad \phi = +51°\ 28' \qquad H = 92.1\ \text{km} \pm 1.7\ \text{km m.e.}$$

This position leads to the following values of the drift motion, the cloud having moved 12.3 km in 20 minutes:

Direction of drift: towards Azimuth 228° from south (N 48° E)
Velocity rate: 10.2 meters a second.

The velocity is low in comparison with the values found for other meteors. It seems that the direction of the wind between 85 km and 92 km changed from W to SW, probably even to S at the height of about 95 km.

The duration of the train was far above the average value found by Trowbridge. About thirty minutes after the meteor's appearance the cloud was faint, but easily visible at places with favorable sky conditions. At Sonneberg, according to the author's observation, the cloud shortly after $23^h\ 30^m$ U.T. was hidden by thin cirrostratus. At Potsdam it was plainly visible at the same time though the clouds of the Milky Way in Aquila interfered. An observer in a favorably situated place reports to have seen the cloud for more than one hour.

Sonneberg, Germany.
Department of the University Observatory, Berlin-Babelsberg.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, *and* H. H. NININGER, Secretary

Further Remarks on Meteoritical Terminology*

By FREDERICK C. LEONARD

At the Organization Meeting of the Society for Research on Meteorites in 1933, I read a short paper entitled "Some Remarks on the Science of Meteoritics,"[1] which caused so much discussion by the members present that it led to the appointment of the Committee on Terminology. At a later date, I published a second article under the heading of "A Glossary of Terms in Meteoritics,"[2] in which I set forth a number of definitions which I favored at that time. The subject of meteoritical terminology came up for consideration again at the Second Annual Meeting in 1934, when the Chairman of the Committee on Terminology, Professor H. H. Nininger, gave an impromptu report on the activities of his Committee. This Committee, by the way, has done a great deal of useful work and is to be commended for the keen interest which it has taken in its assignment. A good terminology is indispensable to progress in any department of knowledge and should be employed by all investigators. As pioneers in meteoritics and as members of

*The revision of a paper delivered at the Fourth Annual Meeting of the Society, University of California at Los Angeles, June 23 and 24, 1936.

The writer wants it understood that the views herein expressed are his own personal views—not necessarily those either of the Society or of its Committee on Terminology, which he appointed at the Organization Meeting in 1933 and of which he is not a member.

[1] *N.S.R.M., P. A.*, **41**, 522-3, 1933.

[2] *Ibid.*, **42**, 477-8, 1934.

this Society, we have a duty to provide our science with a concise and consistent nomenclature, especially since so much confusion prevails in the use of terms in this field. At the Third Annual Meeting in 1935, Professor Nininger delivered a paper on "Terminology in Meteoritics,"[2] which, at his request, I have just re-read here. Thus, the matter of nomenclature has been reviewed at every meeting of the Society held up to date, and is now once more under examination!

At the outset of this discussion I wish to state that while my views regarding three of the most fundamental terms in this science, namely, *meteorite, meteor,* and *meteoroid,* have changed since I wrote the aforementioned papers,[1,2] I still recommend the use of practically all the other definitions endorsed in them. The purpose of the present communication, as its title implies, is to supplement and to bring up to date the remarks contained in the two earlier papers, by revising several of the definitions previously given; by amplifying a number of others; by adding a few new ones; and, finally, by recommending that some old and now superfluous terms be discarded.

I favor Nininger's practice with respect to the words *meteorite* and *meteor,*[3] and, with him, shall define a meteorite as "A mass of solid matter, too small to be considered a planetoid, either traveling through space as an unattached unit, or, having landed on the earth—or some other astronomical body—and still retaining its identity," and a *meteor* as "the light phenomena caused by a meteorite's plunging into the earth's atmosphere from space." This procedure obviates any further need for the old and obsolescent term *meteoroid,* which has been defined as "One of the countless small solid bodies in the solar [and likewise the stellar] system, which become [better, give rise to the phenomena of] meteors on entering the earth's atmosphere" (Webster), and to which valid objections have been raised by a number of authorities. In accordance with the preceding definition of the term *meteorite,* it is apparent that, from the terrestrial point of view, there are two varieties of these bodies, namely (1) those in space and (by inference) those on bodies in the cosmos other than the earth (*e.g.,* the moon); and (2) those in flight in the earth's atmosphere and those on the earth. Evidently but a minute fraction of the meteorites which enter the atmosphere, survives the fiery ordeal of passing through it and lands on the earth's surface in ponderable form.[4]

The advantage of the single term, *meteorite,* to designate all of these small bodies, is that it emphasizes their community throughout the universe and the cosmic character of those here on earth. As I have remarked before,[1] the *essential nature* of a meteorite, if it be sufficiently massive to penetrate the atmosphere and reach the ground as a solid mass, is doubtless unaltered by its transit through the air, even, I may add, if it disintegrates in flight and arrives on the earth as a number of discrete fragments. *Meteorites* are, then, *material bodies,* so called regardless of where they are located—and of whether they have been found and identified as of cosmic origin by man!—whereas *meteors* are the *radiant phenomena of incandescent meteorites in flight in the earth's atmosphere.* It follows from the foregoing definitions that meteorites are the smallest known astronomical bodies and the only ones, other than the earth, of which we can have tactual knowledge.

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[3] Published originally in abstract form in *C.S.R.M., P. A.,* **43**, 464, 1935, and subsequently in full in *P. A.,* **44**, 194-203, 1936.

[4] If necessary, the following distinctions may be made among the several kinds of meteoritic bodies mentioned hereafter; namely, (1) meteorites *in space* or *beyond the earth's atmosphere* (formerly called *meteoroids*); (2) meteorites *in flight* (when incandescent, formerly called *meteors*); and (3) *fallen* meteorites or meteorites *on earth* (still called *meteorites*).

Furthermore, I would employ the word *meteorite* to indicate a *complete individual specimen* as it occurs in nature; *not* a shower of meteorites. So, I would speak of *Canyon Diablo, Arizona, meteorites,* if meaning more than one member of this meteoritic shower, but not the whole shower, and of the *Canyon Diablo fall,* if meaning the entire fall; but I would speak of the *Norfolk, Virginia, meteorite* (or *fall*), since, in this case, only one mass is known to have fallen at the specified time and place and has been recovered. I believe that by following this practice, especially by using the word *fall* to designate *all* the members of a multiple fall or shower collectively, the ambiguity referred to by Nininger[5] can be avoided.[6] We do not know, in any instance, whether the disjunct members of a meteoritic shower were produced by the disruption of a single meteorite in flight or whether they are the survivors of individual members of a swarm of meteorites which entered the earth's atmosphere as such. Pending positive knowledge on the latter point, we may adopt the term *meteoritic swarm* or *system,* which Nininger recommends.[5]

The expression *meteoric swarm* has for many years been current in astronomical literature to designate those aggregations of small meteoritic bodies which, on entering the atmosphere, produce the phenomena of *meteoric showers* (properly so called), such as the Perseids, the Leonids, *et cetera.* These swarms, likewise, should be classified as *meteoritic* (*not* meteoric) *swarms.* While a *meteoric* shower is one thing—*i.e.* luminous phenomena in the earth's atmosphere—a *meteoritic* shower is quite a different thing—*i.e.* a multiple fall of meteorites (bodies which have reached the earth), like, *e.g.,* the Estherville, Iowa, and the Holbrook, Arizona, showers.

As to the clouds sometimes left in the wake of unusually large, incandescent meteorites in flight: these too, obviously, should be styled *meteoritic,* rather than meteoric, *clouds* (*cf.* the expressions *meteoritic craters, post,* and *meteoritic dust*).

I strongly advocate the retention of the familiar and useful terms *siderite, siderolite,* and *aërolite* to distinguish from one another the three main classes of meteorites, namely the all-metal (principally nickeliferous iron) kind, the metal-stone kind, and the practically all-stone kind; but I would never employ the word *aërolite* as a synonym or substitute for *meteorite,* as has often been done; I would restrict the former term to mean exclusively a *stony* meteorite, and use the latter one only in the general sense.

Although the noun *meteoritics* (meaning the science of meteorites and, we should add, their luminous phenomena, called meteors) is now widely accepted and is contained in the latest edition of Webster's *New International Dictionary,* and probably in some others, it still fails to find favor with a few authorities; why, I do not know, for none of them, to my knowledge, has ever proposed a shorter, simpler, or better term. Surely *meteoritology, meteoritonomy,* and *meteoritography,* which, I suppose, are etymologically possible, are not preferable to it, because of their length and difficulty to pronounce (not to mention their derivatives!); nor are the three almost obsolete words, *aërolithology, aërolitics,* and *astrolitholo-gy,* to which reference will be made again at the end of this paper. *Meteoritical* (pertaining to meteoritics, *not* meteorites), is simply the adjective derived from *meteoritics.*

If we adopt the noun *meteoritics* and its adjective *meteoritical,* we are rhetorically bound to accept *meteoritician* or *meteoriticist* as the designation for a spe-

[5] *P. A.,* **44**, 198, second, third, and fourth paragraphs.

[6] *Falls* include of course *finds,* since every recovered meteorite, irrespective of whether it was observed to fall or not, fell some time, and so constitutes a member of a fall, or a whole fall, as the case may be.

cialist in meteoritics! Between the synonyms *meteoritician* and *meteoriticist* there is not much choice. While *meteoritician* has probably more analogues in the language, such, *e.g.*, as *mathematician, acoustician,* and *statistician, meteoriticist* is the more euphonious word and the easier one to pronounce (besides, it has a counterpart in *physicist*). On the whole, the advantage seems to lie with *meteoriticist,* which may, accordingly, be regarded as the slightly superior term. My late friend, Dr. Walter B. Scaife, a member of this Society, once proposed in conversation the word *meteoritist* as the title for one versed in meteoritics. Regardless of whether that term is seriously to be countenanced in this connection, I should record that it has a parallel in the already existing word *meteorist,* which is defined in several dictionaries as an authority on meteors!

The adjective *meteoritic* is now almost as well established as the noun *meteorite.* The use of this adjective dates back at least to the year 1890, when Sir J. Norman Lockyer published his now famous work, *The Meteoritic Hypothesis.* I must, however, reiterate that the three adjectives *meteoric* (pertaining to meteors), *meteoritic* (pertaining to meteorites), and *meteoritical* (pertaining to meteoritics), regardless of their similarity in form, are in no sense synonymous. The adjective *meteorital,* which is found in several dictionaries, is an acceptable (though by no means a necessary) substitute for *meteoritic.*

Apropos of the words *meteorite* and *meteoritic,* I want to voice a plea that craters of unquestionably meteoritic origin be denominated *meteorite* (or, better, *meteoritic*) *craters* instead of *meteor craters,* as they now commonly are. Let, *e.g.,* the remarkable topographical feature near Winslow, Arizona, be called the *Meteorite* (or *Meteoritic*) *Crater* of Arizona—*not* the *Meteor Crater*—since this was caused, in all probability, by an enormous meteorite or a swarm of meteorites —*not* by a meteor! In view of the preceding definitions, the use of the noun *meteor* or of the adjective *meteoric,* in reference to a geological formation like the Canyon Diablo crater, is as absurd as it is improper.

As to the common words *bolide* and *fireball,* which are exact synonyms, meaning unusually large, brilliant, and, occasionally, detonating "meteors," which accompany meteorites that may or may not reach the ground, I favor the former, especially for technical writing; but I would discard the popular terms *shooting-* and *falling-star,* employed to designate the ordinary "run" of meteors, since these names are misleading both to the public and to the elementary student of astronomy, who is taught that a star is a great body like the sun. There is no reason why the technical and preferable term *meteor* should not replace the expressions *shooting-* and *falling-star,* even in popular writing and everyday speech. It is scarcely necessary to say further that *bolide* and *fireball* should never be used as synonyms or substitutes for *meteorite,* for the obvious and sufficient reason that bolides or fireballs are *meteors* (*i.e. light phenomena, not* material bodies) of extraordinary magnitude.

I would employ the term *meteoric astronomy* to mean the science or the study of meteors, as distinguished from meteorites, in accordance with the present definitions. Meteoric astronomy is an integral part of meteoritics (the science of meteorites and their concomitant phenomena, called meteors), which, epistemologically considered, is itself a branch of astronomy, as I have earlier pointed out[1]—as much so as is, *e.g.,* astrophysics. Practically regarded, meteoric astronomy is that province of astronomy—and likewise of meteoritics—which treats of meteors; it is, as Nininger puts it,[2] "the astronomical aspects of meteoritics," whereas meteoritics has intimate contacts with geology (particularly with mineralogy and with petrology) as well as with astronomy. Meteoritics is, indeed, as it has frequently

been described, a "borderland science," between and partially overlapping the territories of astronomy and geology. The mutual importance and the interdependence of meteoritics and meteoric astronomy are so manifest as to call for no further comment here.

The convenient term *meteorode* has recently been "coined" by Nininger[7] to designate a concretionary nodule composed of partially metamorphosed (presumably geologically altered) meteoritic material. Since, to my knowledge, he is the only investigator who has had occasion to use this term up to date, I will quote his own definition of it from the paper cited in the footnote[7]: "A nodule of meteoric [*i.e.* meteoritic] origin, consisting of an outer zone of ferrite enclosing the siliceous constituents of the original meteorite." He applied the word to the unique and remarkable variety of specimens which he recovered (about 1929) in the vicinity of the famous Brenham Township, Kiowa County, Kansas, siderolitic shower (known since 1885).[8]

An interesting account of the history of the term *Widmanstätten figures*, dating back from the present time to the year 1813, is given by our distinguished English member, Dr. L. J. Spencer of the British Museum, in a paper published in *The Mineralogical Magazine*, **23**, on pp. 331-3, 1932-34. He finds that this term has made its appearance in the literature in no less than fourteen guises! In this respect, its history is not unlike that of some other meteoritical expressions! Moreover, as Spencer points out, not one of these fourteen spellings is correct, and, while the man usually referred to as Widmanstätten doubtless did discover the figures, he himself published nothing on the subject. The first published mention of these etched figures seems to have been made by one K. A. Neumann (not to be confused with J. G. Neumann, in whose honor the so called *Neumann lines* were named) in 1812. I will quote from Spencer's paper:

"As a matter of fact the name of the man who has been commemorated in this connection for the past hundred and twenty years, was not Widmanstätten, Widmannstätten, Widmanstädten, or Widmannstädten, as given by his contemporaries, but that of a noble family, Widmanstetter, of Graz in Styria. His full name and title were Alois Joseph Franz Xaver Beckh, Elder [Baron] von Widmanstetter. He was born at Graz on July 13, 1754, and died in Vienna on June 10, 1849."

In the light of the circumstance that the multifarious variations of this man's name or title, extant for nearly a century and a quarter, are only misspellings, it is undeniably correct to call the crystallization figures of a typical siderite, *Widmanstetter figures!* Furthermore, this form possesses the added advantage of typographical simplicity!

Still another word remains to be discussed which, chiefly through the investigations of our fellow member, Dr. L. J. Spencer, and others, in late years, has been conspicuous in the literature of meteoritics: I mean the term *tektites*. At my request, Dr. Spencer has kindly contributed to this meeting a paper on "The Tektite Problem," which contains a valuable résumé of its present status and from which I need not quote, for the paper is scheduled to be read here.[9] *Tektites*, called also *moldavites, billitonites, australites, Darwin glass, indochinites, rizalites, et cetera*, may be defined as small, apparently corroded fragments of natural glass, which are found at widely separated places on the earth and which, because of the

[7] *Trans. Kansas Acad. Sci.*, **32**, 63-7, 6 figs., 1929: "Notes on Oxidation of Certain Meteorites; The Formation of Meteorodes."

[8] It may be argued that *meteoritcode* would be a more fitting, and thus, in spite of its greater length, a better name for these bodies than *meteorode*.

[9] And has since been published in full in the *C.S.R.M., P. A.*, **44**, 381-3, 1936.

difficulty, or impossibility, of explaining them otherwise, have been supposed by some investigators to be of cosmic origin, even though no all-glass meteorite has ever been observed to fall. In the last analysis, proof of the extramundane character of any specimen must depend upon whether it, or something very like it, has been seen to fall; otherwise, it must be doubtful, always, whether a piece of material, which cannot be identified either with any known sort of terrestrial substance or with any recognized kind of meteorite, is itself meteoritic. Hence, the problem of the tektites remains unsolved, and so will continue until such time as one of these bits of glass either is observed to fall from the skies or is traced to an earthly source.

Finally, I come to the consideration of some dozen nouns which have crept into the language and found their way into dictionaries but which, in company with all their derivatives, should, in my opinion, be dropped from the nomenclature of meteoritics and be consigned to oblivion! My reason for making this statement is that the words about to be mentioned are unnecessary, and, in most cases, confusing synonyms for more satisfactory terms which have superseded them in common use. I append an alphabetical list of these words (some of which are characterized, even in modern dictionaries, as obsolescent), and their definitions:

Aërolith: an old synonym for *aërolite* (and, incorrectly, by extension, *meteorite*).

Aërolithology (literally, the science of aëroliths): a synonym for *meteoritics* (the latter term having been proposed by Farrington in his *Meteorites,* p. 5, 1915).

Aërolitics (literally, the science of aërolites; a term due to Maskelyne): another synonym for *meteoritics.*

Aërosiderite: the old term for *siderite.*

Aërosiderolite: the old term for *siderolite.*

Astrolithology (literally, astronomical lithology; a term due to Shepard): another synonym for *meteoritics.* (Concerning the words *aërolitics* and *astrolithology,* see Farrington, *op. cit.,* p. 5.)

Falling-star: a popular synonym for *meteor* (*cf. shooting-star*).

Meteoroid: a meteorite outside of the earth's atmosphere. This term is no longer required, as has been explained, *ante.*

Meteorolite (literally, a meteoric stone): a synonym for either *meteorite* or *aërolite;* hence, ambiguous and superfluous (*cf. uranolite* and *uranolith*).

Shooting-star: another popular synonym for *meteor* (*cf. falling-star*).

Uranolite and *uranolith* (literally, a heaven stone): obsolescent synonyms for either *meteorite* or *aërolite;* hence, ambiguous and superfluous (see Young's *General Astronomy* and other old textbooks, and *cf. meteorolite*).

Moreover, the following technical terms, which may legitimately be employed to differentiate certain *sub*classes of meteorites from one another, should never be used as synonyms for any of the three primary types, siderites, siderolites, and aërolites, to which the terms in question respectively relate: *achondrite, asiderite, ataxite, chondrite, hexahedrite, holosiderite, lithosiderite, mesosiderite, octahedrite, pallasite, sporadosiderite,* and *syssiderite.* For details concerning the words just enumerated, and many others, consult Farrington, *op. cit.,* Chap. XII, on the "Classification of Meteorites," pp. 197-204.

1936 November

Secretary's Office: Nininger Laboratory, 1955 Fairfax Street, Denver, Colorado
Editorial Office: Department of Astronomy, University of California at Los Angeles

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

The Non-Expanding Universe

In my judgment the discussion of the chief advocates of the hypothesis that the universe is expanding are more those of a special pleader than of a scientist who presents the observational data without bias from which a theory is deduced. A theory so formulated does not admit of exception, and as Sir James Jeans remarks "No number of phenomena can prove a theory, but one phenomenon can disprove it."

The argument for the Expanding Universe is that spectrum analysis of the light received from nebulae shows a shift of the Fraunhofer lines toward the red end of the spectrum. It is admitted that there are five exceptions to the general recession of the nebulae but that these nebulae are close to us, and are probably of no real importance and may be due to accidental causes.

Since one of these five nebulae is the great nebula in Andromeda, it would hardly seem fair to neglect it, and if our galaxy is overtaking Andromeda, it should be noted that the nebula N.G.C. 584, distant 11,400,000 light years, which is nearly in line with N.G.C. 224 (Andromeda) and N.G.V. 221, both approaching, has a receding speed of 1800 miles per second.

N.G.C. 584, distant 11,400,000 light years, should have, according to theory, a recessional speed of approximately 1,000 miles per second, and, if our galaxy is approaching it, the apparent speed of recession 1,800 miles per second, would be somewhat lessened, but it is already far above the theoretical speed of 1,000 miles per second.

Eddington mentions a nebula in Boötes which is receding at 24,200 miles per second. If cosmical repulsion is driving us apart, then our galaxy must be moving away from the Boötes nebula. But N.G.C. 6341 in Hercules is approaching our galaxy at 180 miles per second, and is nearly in line with the Boötes nebula. So cosmical repulsion is driving us away from Boötes nebula and at the same time we are approaching Hercules.

Now we come to an astounding statement by Eddington in "New Pathways to Science," page 211, namely, we must not trust observational data until they are confirmed by theory.

Eddington states (page 212) that there is nothing in our present knowledge of physics that gives a hint of an alternative cause for the red shift of the nebular spectra, and is scornful of the General Catalogue of Radial Velocities, because it heads the column "Apparent Radial Velocities," yet Sir James Jeans in the "Mysterious Universe," page 72, says "other things than recession are capable of reddening the spectra, and gives several alternative causes for this reddening.

We expect the 200-inch telescope to reveal other nebulae far more distant than those now observed, and under the theoretical rule of increasing recessional speeds, we will soon be nearing the velocity of light. We believe the entire mass of the universe is limited and Eddington estimates the entire number of electrons

to be 136×2^{256}. It is difficult to believe that these enormous speeds are possible in a universe of limited mass.

Since motion is relative, our galaxy must be doing a curious dance in space to conform to the various speeds of the nebulae that surrounds us.

C. S. STANWORTH,
Comdr. U.S.N., Retired.

Notes from Amateurs

How to Find Venus at Midday without Setting Circles

On two occasions I have located the planet Venus in the two-inch refractor I use and in my six-inch reflector. Neither telescope has setting circles, but by the following method, finding Venus many hours before sunset has been easy.

First, look in some astronomical publication, such as POPULAR ASTRONOMY, which contains "Planet Notes," or in the *American Ephemeris and Nautical Almanac* and find the day and hour that Venus and the moon are in conjunction. Next, go outside and find the moon with the naked eye. The moon at this position in its orbit will be a rather thin crescent, and I have found a pair of light amber sun glasses to be a great help in locating the moon, because they make it stand out in greater contrast with the blue sky. After the moon is located with the naked eye, set the telescope on it and Venus can then be found quickly by merely sweeping the sky a few degrees from the moon in the direction indicated by the "Planet Notes" or the *American Ephemeris.*

For example, as found in the January "Planet Notes," published in the December issue of POPULAR ASTRONOMY, we find that on January 16, 1937, at 9:00 A.M., C.S.T., Venus will be in conjunction with the moon and will at the time be 6°.5 south of the moon. Now, say we make the observation shortly after noon, the first thing to do is to set the telescope on the moon, using the eyepiece that will give the largest field of view. Then move it to a position about 6°.5 south of the moon, this distance being estimated, and sweep the sky with it just west of this point, the distance being only a few degrees, depending on the time elapsed since the conjunction. If you make the observation before the conjunction, go through the same procedure, except look for Venus on the east side of the moon. By this method Venus can be located best on the day of conjunction with the moon. After Venus is once picked up you can substitute a higher power eyepiece for a better view of the planet, its disc or its crescent by day.

The above, on first reading it over, may seem complicated, but it really is not. To see Venus, brilliantly shining in a background of bright blue instead of the darker sky after sunset is quite a satisfaction in itself.

CHARLES H. BROCKMEYER, JR.

Fredonia, Kentucky, 1936 December 11.

Junior Astronomy News for December, 1936, published by the Junior Astronomy Club, with headquarters at the Hayden Planetarium, New York City, consists of twelve mimeographed sheets bound in paper cover. It contains a number of articles written in an easy and simple style, quite appropriate for beginners. This Club is to be commended for its continued activity and enthusiasm.

General Notes

Captain C. S. McDowell, U. S. N., Supervising Engineer of the construction of the 200-inch telescope, delivered a lecture before The Franklin Institute on Thursday evening, December 10, 1936, on the subject "Building the 200-inch Telescope."

Ambrose Swasey Honored by Colleagues

Ambrose Swasey, founder and chairman of the Warner & Swasey Co., Cleveland, manufacturers of telescopes and turret lathes since 1880, was awarded the Hoover Gold Medal, awarded by the National Engineering Societies "to a fellow engineer for distinguished public service" on Wednesday, December 2, at Hotel Astor, New York City.

The presentation to Mr. Swasey, who celebrated his 90th birthday on December 19, was the highlight of the annual winter meeting of the American Society of Mechanical Engineers. Conferring the medal upon this veteran industrialist in the presence of former President Herbert Hoover, for whom it was named, Gano Dunn, chairman of the board of award, representing the A.S.M.E., the A.S.C.E., the A.I.M.E., and the A.I.E.E., recalled Mr. Swasey's services "rendered out of a love for and devotion to humanity itself."

The Hoover medal was being awarded to Mr. Swasey, he said, because the board felt that he was "worthy to be held up for all time as an example of the type of engineer the Hoover medal was established to honor." Contrasting the career of the machine tool and telescope builder with that of Mr. Hoover, he explained that Mr. Swasey "had won his spurs in the precision workshop rather than in the wilds of distant climes."

"Throughout his whole career, however, there has shone in his heart no less than in Herbert Hoover's that love of his fellow man which has been the inspiration of a lifetime of public service outside of his work as an engineer," said Mr. Dunn. "His years are many, but he is rich in the spirit of youth. His spirit constitutes an example to his fellows who held him in personal affection no less high than they held him in honor. It is not an accident that he has long been known as 'The Knight of the Kindly Heart'."

On the same occasion Mr. Swasey was presented with the Medal of Honor of the Verein Deutscher Ingenieure, the leading engineering society in Germany.

The following is the text of the formal presentation of the Hoover Gold Medal to Ambrose Swasey:

AMBROSE SWASEY

From a New England heredity, environment, and training, Ambrose Swasey derived qualities of character that have filled his life with those distinguished public services for which his fellow engineers confer upon him the second award of the Hoover Gold Medal.

Mr. Swasey represents the Yankee mechanic brought to its fairest flower and fullest fruit. In a machine shop in Exeter, New Hampshire, he first disciplined his native skill in precise and resourceful craftsmanship. Here he met his partner of mature years, Worcester Reed Warner, with whom, in 1869 he went to Hartford, Connecticut, where, in that famous training school of machine tool builders and precision manufacturers, he completed the period of his life during

which he labored under the direction of others and from which he departed with Warner in 1880 to form a long and fruitful partnership, the Warner and Swasey Company, of Cleveland, Ohio.

Into the products of this partnership, machine tools and the structural parts of astronomical instruments, including many of the world's finest and largest telescopes, was put the ingenuity of correct design, the precision of skilled craftsmanship and the practicability of every day use that have made and sustained the reputations of the famous founders.

As technical success and material prosperity crowned honest and intelligent labor, Mr. Swasey grew in moral and spiritual stature and extended his influence and personality into a long life of distinguished services to the industry in which he worked, to engineering, to science, to research, to his church, to education, and to public affairs. With all of these he shared his fortune as well as his intellect and the vigor of his personality. In 1914 he established the Engineering Foundation, to which his personal contributions to date have amounted to more than half a million. In this gift alone he has made permanent his influence to future generations.

For ninety years Mr. Swasey's capacity for friendship and the engaging qualities of his personality have endeared him to men in all walks of life. The list of his honors is long and impressive, but on it is none that describes him so well as that bestowed by a group of personal friends that included John Brashear and John R. Freeman—Knight of the Kindly Heart.

The Rittenhouse Astronomical Society of Philadelphia held a regular meeting of the Society on Friday, December 11, in the Hall of The Franklin Institute. The program was an address entitled "Astronomical Motion Pictures" (illustrated) by Robert McMath, Director of the McMath-Hulbert Observatory of the University of Michigan. The speaker for this occasion is one of America's outstanding amateur astronomers, and has developed much apparatus for filming the heavenly stars. He explained these methods and showed, among other films, those of the sun and solar prominences, which attracted great attention at the Harvard Tercentenary meeting of the American Astronomical Society.

Centenary of the Death of John Pond

It is not perhaps generally known that two Astronomers Royal lie buried in the same grave in the old churchyard of St. Margaret's Church, Lee. The following extract, for which we are indebted to *The Times* of 1936 September 15 (taken from *The Times* of September 15, 1836), explains why Pond was buried in Halley's grave:

> Mr. John Pond.—On Tuesday last the remains of the late astronomer royal were deposited in the churchyard of Lee, Kent. They were attended to the grave by his successor, Professor Airy, by the three assistants of the deceased, by Mr. Henry Warburton, M.P., together with a few relatives and personal friends. Mr. Pond having always expressed a desire that the place of his interment should be the beautifully situated churchyard of Lee, application was made to the rector for his consent to carry the wish into execution, but on account of the place being small, and already so full that room was with difficulty found for the actual parishioners, permission was not in the first instance granted. On reflection, however, the rector, the Rev. Mr. Lock, recollecting that the tomb of a former astronomer royal, the celebrated Dr. Edmund Halley, who died in 1743, and was buried at Lee, had never been tenanted by a single individual except that distinguished philosopher himself, and his wife and daughter, and considering that, as 93 years had elapsed since he was

therein deposited, it was highly improbable that any claim would be made in behalf of his descendants, with very good feeling directed that the receptacle of Dr. Halley's remains should also become that of one of his successors. Thus, by an accident and remarkable coincidence, the material part of the two philosophers, who held the same appointment, who, while living, inhabited the same dwelling, now rests in the same eternal mansion.—*From a Correspondent.* (*The Observatory,* November, 1936.)

The Galaxy

The following paragraph, which is the concluding one in a paper on the above topic by Professor J. S. Plaskett, one of the best qualified astronomers of the present day for a discussion of this subject, is given here for the benefit of our readers who may not have access to *Scientia.*

Summarizing finally, we have as the main feature of the Galaxy a great central disc of stars, irregularly distributed in groups or clusters with a general underlying field of stars, with possible spiral structure. The effective diameter is 30,000 parsecs with a thickness 1,000 to 2,000 parsecs, but with a spheroidal enlargement at the centre 5,000 parsecs or more in thickness. There are however scattered high velocity stars and the globular clusters extending beyond these boundaries 5,000 to 10,000 parsecs and a thin stratum of absorbing material some 500 parsecs in thickness is interspersed among the stars near the central plane. While these conclusions have been fairly definitely stated, the proposed model must be considered only as a preliminary attempt at the solution of this difficult but fundamental astronomical problem. In view of the changes that have occurred in our conceptions of the Galaxy during the past twenty years, it would be very rash to predict even approximate finality. The present concept however has a certain unity and probability and it can only be hoped that it makes a useful introduction to more complete knowledge. (*Scientia,* December, 1936.)

Book Reviews

Cosmogonies of Our Fathers, by Katherine Brownell Collier, Ph.D. (Columbia University Press, New York. $5.00.)

"Cosmogonies of Our Fathers," by Katherine Brownell Collier, Ph.D., is a painstaking and scholarly reviewal of seventeenth and eighteenth century efforts to harmonize new scientific discoveries with the then accepted Scriptural doctrines concerning the origin and nature of the universe. To use words of Dr. Collier, it is "A recapitulation of these forgotten hypotheses, which deflected multitudes from the main course of their centuries' intellectual progress . . ." Many are nowadays too pre-occupied with the further pursuit of scientific knowledge to reflect sufficiently on such phases of the evolution of cosmological ideas as are presented by Dr. Collier. A commendable service has undoubtedly been rendered in systematically portraying the attempts of these centuries to reconcile science and religion.

The book is divided into two parts. Part I is chiefly given over to hypotheses of various thinkers, emphasis always being directed to those influenced by the conflict between science and religion. The order of presentation is in general chronological. Part II is a "Topical Review" of such subjects as "The Heavens," "Celestial Influences," "Primeval Light," "Classification of Matter," "Spontaneous Generation, Permanence of Species and Fossils," "The First Man," and other moot questions of the day.

It is interesting to note that Buffon in 1744 proposed that comets grazing the sun's limb drew forth the material from which planets formed. How oddly this

resembles our present popular theory of the close approach of another star, but how utterly inadequate a comet would be to produce this effect! We would, however, prefer this theory to that attributed to Robert Fludd (1617), to the effect that original light encircling the universe cleared the lowest heavens of shadows by forcing them toward the center of the universe, thus forming the hard and cold ball of the terrestrial globe!

Dr. Collier's volume strikingly portrays the uncertainty and conflict in the minds of our forefathers concerning the nature of the physical universe, and the relationship of science and religion. After reviewing the book, we feel glad to be living in the twentieth century instead of the seventeenth or eighteenth. Will our ideas seem as archaic and futile to our descendants?

R. S. Z.

Katalog und Ephemeriden Veränderlicher Sterne fur 1937, by H. Schneller. (Ferd. Dummlers Verlagsbuchhandlung, Berlin.)

This useful handbook for variable star studies increases in size from year to year with the increasing number of variable star discoveries. The present issue in its 217 pages contains references to 6968 stars. Table I occupies the major part of the volume and lists the long-period variables arranged according to right ascension in the several constellations, which are arranged in alphabetical order, thus making the finding of a particular star most convenient. Table II contains a list of stars of period less than 100 days, also arranged alphabetically by constellations. Table III lists the eclipsing variables, similarly. Table IV is a recapitulation of all variables arranged according to right ascension; this is divided into two parts: stars north of —23°, and stars south of —23°.

As already intimated this publication is practically indispensable to those concerned with investigations relating to variable stars.

The volume is issued from the Berlin-Babelsberg Observatory. One misses the familiar name of R. Prager, who was responsible for the volume for many years.

Star Maps from Duncan's *Astronomy* have been issued as a four-page bound pamphlet and may be purchased from the publishers of that text.

Kleine Planeten, for the year 1937, has recently been received. This publication has through the years become a familiar and most useful publication for workers who are concerned with the asteroids. The issue for 1937 contains definite elements for 1380 of these objects, as compared with 1344 in the issue for 1936, showing that a large amount of new work has been done during the year. In addition to the table of elements there is a table giving the date of opposition for each asteroid, which comes to opposition in 1937. Also there is a table giving ephemerides for the asteroids through a period of forty days near the date of opposition which enable the observer to locate these objects at the most favorable period. More detailed ephemerides are given for the first four, namely Ceres, Pallas, Juno, and Vesta.

The work consists of 146 pages, and is issued by the Astronomischen Rechen-Institute at Berlin-Dahlem, Germany. This is an important and much appreciated addition to our library.

Cosmic Rays was the subject chosen by P. M. S. Blackett, Professor of Physics, Birbeck College, University of London, for the Halley Lecture delivered on June 5, 1936. The text of this lecture has been issued by the Oxford Univer-

sity Press, 114 Fifth Avenue, New York City, and may be purchased for seventy-five cents. It consists of twenty-five pages of text and figures and two pages of plates. A careful analysis of the present status of thought regarding these phenomena is given, and the problems yet awaiting solution are clearly set forth.

Southern Stars, Vol. 2, No. 9, the Journal of the New Zealand Astronomical Society, the issue for November, 1936, is largely devoted to suggestions for observing the annular eclipse of the sun on December 14, 1936. The path of this eclipse passed almost centrally over Australia and over the northern part of New Zealand. Other items in this issue are planetary phenomena for November, 1936, a review of the fourth edititon of "Amateur Telescope Making," a note concerning the establishing of an observatory by France in the southern hemisphere, and an abstract of a lecture on the subject, "The Restless Universe." It is an interesting number.

Interpolation and Allied Tables is a pamphlet consisting of certain pages taken from the *Nautical Almanac* (British) for 1937. The paging in the *Nautical Almanac* is preserved and the pamphlet comprises pages 839 and 784 to 809, inclusive, and 926 to 941, inclusive. The last group of pages consists of explanations, giving the theory upon which the computations are based. These tables are highly technical and require expert intelligence in their application. For such as have use for them, the tables are presented in this pamphlet in a very much more convenient form than the larger complete copy of the *Nautical Almanac* affords. Although the tables, because of their technical character, are applicable to a limited class of problems, they will in the cases in which they can be used reduce the labor of computations enormously and thus demonstrate their great value. We appreciate the courtesy of the Superintendent of H. M. Nautical Office, London, in sending us a copy for our library.

Games and Stunts for All Occasions, by William P. Young and Horace J. Gardner. (J. P. Lippincott Company, Philadelphia.)

It may seem that a review of a book having the above title is not in keeping with the usual tenor of an astronomical magazine. It is true that this volume does not contribute anything to the science, but, since astronomers are human beings, it may contribute something to the scientists. For, consider the plight of an astronomer on a long winter evening when the sky is cloudy. Then he cannot sit at his telescope as he is traditionally supposed to do. It is then that he may turn his attention to such mundane things as are suggested by the above title. Indeed, it is reported that a certain well-known, though somewhat remote, astronomical staff has been known, on occasions which promised unusual recreation and surcease from continuous observing, to meet and declare the sky *officially* cloudy. For such cloudy nights, actual or imagined, a copy of the book under consideration would play an important part. It might, therefore, well be given a place in the observatory library. Perhaps, however, it should occupy an obscure place, lest the visitor, to whom the astronomer is super-human, suffer disillusionment.

Publications Received.—The publishers of POPULAR ASTRONOMY hereby acknowledge the receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

Veröffentlichungen der Universitäts-Sternwarte zu Berlin-Babelsburg, Band XI, Haft 3. Epsilon Aurigae von M. Güssow.

Veröffentlichungen der Universitäts-Sternwarte zu Bonn, No. 29. Spektrale Intensitäts-Messungen an 1984 Sternen des Südhimmels, von F. Becker und A. Kohlschütter.

Contributions from the Mount Wilson Observatory:

No. 533. "Radiation from the Planet Mercury," by Edison Pettit and Seth B. Nicholson.

No. 534. "A Scale of Wave-Lengths in the Infra-Red Solar Spectrum," by Harold D. Babcock, Charlotte E. Moore, and Wendell P. Hoge.

No. 535 and 536. "New Elements for the Spectroscopic Binary Boss 6142," by Roscoe F. Sanford.

No. 537. "Tables for Intensities of Lines in Multiples," by Henry Norris Russell.

No. 538. "Equilibrium of Stellar Atmospheres under a Temperature Gradient," by Rupert Wildt.

No. 539. "Notes on the Spectra of Several Long-Period Variable Stars at Various Phases of their Light-Curves," by Paul W. Merrill.

No. 540. "Absorption-Line Intensities in B-Type Stars," by E. G. Williams.

No. 541. "Classification of the B-Type Stars," by E. G. Williams.

No. 542. "Investigations on Proper Motions," by P. Th. Oosterhoff.

No. 543. "Photoelectric Magnitudes of the Brightest Extra-Galactic Nebulae," by Albert E. Whitford.

No. 544. "The Provisional Elements of 16 Spectroscopic Binaries," by William H. Christie.

No. 545. "Spectrum of Nova Herculis 1934, April-November, 1935," by Walter S. Adams and Alfred H. Joy.

No. 546. "Analysis of the Spectrum of Singly Ionized Samarium," by Walter Albertson.

Lick Observatory Bulletin:

No. 483. "Fourth Catalogue of Spectroscopic Binary Stars," by J. H. Moore.

Annals of Harvard College Observatory:

Vol. 90, No. 7. "A Survey of Variable Stars in Milky Way Fields 233 & 187," by Henrietta H. Swope.

Vol. 100, No. 6. "The Henry Draper Extension," by Annie J. Cannon.

Vol. 104, No. 2. "Observations of Variable Stars by the American Association of Variable Star Observers," by Leon Campbell.

Harvard College Observatory Circular:

No. 410. "The Physical State of the Solar Chromosphere," by G. G. Cillie and D. H. Menzel.

No. 417. "The Structure of the Atmosphere of Zeta Aurigae," by D. H. Menzel.

Publications of the Yerkes Observatory:

Vol. VIII, Part 1. "Parallaxes of Eighty Stars," by Oliver J. Lee.

Part 2. "Measurements of Double Stars," by George Van Biesbroeck.

Communications to the National Academy of Sciences:

No. 118. "A Second Law of the Motions of Eruptive Prominences," by Edison Pettit.

No. 119. "Selective Absorption of Starlight by Interstellar Clouds," by Frederick H. Seares.